DEC 7 1923

Vol. VI, No. 6 PSYCHOLOGICAL REVIEW PUBLICATIONS DECEMBER, 1923

Journal of Experimental Psychology

EDITED BY

JOHN B. WATSON, 244 MADISON AVE., NEW YORK CITY
HOWARD C. WARREN, PRINCETON UNIVERSITY (*Review*)
JAMES R. ANGELL, YALE UNIVERSITY (*Monographs*)
SHEPHERD I. FRANZ, GOVT. HOSP. FOR INSANE (*Bulletin*) AND
MADISON BENTLEY, UNIVERSITY OF ILLINOIS (*Index*)

ADVISORY EDITORS

H. A. CARR, UNIVERSITY OF CHICAGO; RAYMOND DODGE, WESLEYAN UNIVERSITY; KNIGHT DUNLAP, THE JOHNS HOPKINS UNIVERSITY; H. S. LANGFELD, HARVARD UNIVERSITY; E. L. THORNDIKE, COLUMBIA UNIVERSITY.

CONTENTS

Sex Characteristics of Systolic Blood Pressure Behavior: WILLIAM M. MARSTON 387

The Cardio-Pneumo-Psychogram in Deception: J. A. LARSON . . . 420

The Influence of Constitutional Factors on Behavior: SANTE NACCARATI and HENRY E. GARRETT 455

The Effects of Underlearning Upon Short- and Long-Time Retentions: EDWARD CHACE TOLMAN 466

PUBLISHED BI-MONTHLY BY

PSYCHOLOGICAL REVIEW COMPANY

PRINCE AND LEMON STREETS, LANCASTER, PA., AND PRINCETON, N. J.

Entered as second-class matter, July 3, 1916, at the post-office at Lancaster, Pa.

Psychological Review Publications

EDITED BY

HOWARD C. WARREN, PRINCETON UNIVERSITY (*Review*)
JOHN B. WATSON, 344 MADISON AVE., NEW YORK (*J. of Exp. Psych.*)
JAMES R. ANGELL, YALE UNIVERSITY (*Monographs*)
SHEPHERD I. FRANZ, GOVT. HOSP. FOR INSANE (*Bulletin*)
MADISON BENTLEY, UNIVERSITY OF ILLINOIS (*Index*)

WITH THE CO-OPERATION OF

MANY DISTINGUISHED PSYCHOLOGISTS

PSYCHOLOGICAL REVIEW

containing original contributions only, appears bimonthly, January, March, May, July, September, and November, the six numbers comprising a volume of about 480 pages.

PSYCHOLOGICAL BULLETIN

containing abstracts, critical reviews of books and articles, psychological news and notes, university notices, and announcements, appears monthly, the annual volume comprising about 720 pages. Special issues of the BULLETIN consist of general reviews of recent work in some department of psychology.

JOURNAL OF EXPERIMENTAL PSYCHOLOGY

containing original contributions of an experimental character, appears bimonthly, February, April, June, August, October, and December, the six numbers comprising a volume of about 480 pages.

PSYCHOLOGICAL INDEX

is a compendious bibliography of books, monographs, and articles upon psychological and cognate topics that have appeared during the year. The INDEX is issued annually in May, and may be subscribed for in connection with the periodicals above, or purchased separately.

PSYCHOLOGICAL MONOGRAPHS

consist of longer researches or treatises or collections of laboratory studies which it is important to publish promptly and as units. The price of single numbers varies according to their size. The MONOGRAPHS appear at irregular intervals and are published into volumes of about 500 pages.

Philosophical Monographs: a series of treatises more philosophical in character.

Library of Philosophy, Science and Philosophy: a series of bound volumes.

ANNUAL SUBSCRIPTION RATES

Review: $4.00 (Foreign, $4.50). Review and Bulletin: $8.00 (Foreign, $8.50)
Journal: $4.00 (Foreign, $4.50). Review and Journal: $8.25 (Foreign, $8.75)
Bulletin: $5.00 (Foreign, $5.25). Journal and Bulletin: $9.00 (Foreign, $9.50)

Any one of the above with Index: $1.25 additional.
Any two of the above with Index: $1.00 additional.

Review, Bulletin, and Journal: $12.50 (Foreign, $13.25).
Review, Bulletin, Journal, and Index: $13.50 (Foreign, $14.25).
Current numbers of Review or Journal, 60c; Bulletin, 50c; Index, $1.50
Psychological Monographs: $5.50 per volume (Foreign, $5.80).
Current numbers of Monographs vary according to size.

Subscriptions, orders, and business communications may be sent direct to the

PRINCETON, N. J. OFFICE

PSYCHOLOGICAL REVIEW COMPANY

Foreign agents: G. E. STECHERT & CO., London (9 Star Yard, Carey St., W.C.) Paris (76 bis rue de Condé)

ExP

Journal of
Experimental Psychology

VOL. VI., No. 6 December, 1923

SEX CHARACTERISTICS OF SYSTOLIC BLOOD PRESSURE BEHAVIOR

BY WILLIAM M. MARSTON

Washington, D. C.

1. INTRODUCTION

After retiring from War work with applied Deception Tests, in 1919, the writer brought the tests back to the Harvard laboratory for further psycho-physiological analysis. From the Court's point of view, it is never sufficient to announce that a certain test 'works'; the Court demands—and quite justly—that a scientific analysis of constituent elements shall be made, so that the final result may be based upon what is legally known as 'common knowledge.' Most jurists are prone to the belief that the applied psychologist is attempting to foister upon the law courts a sort of patent medicine, the ingredients of which have been determined by chance discovery, and are not fully understood even by the inventor himself. It must be admitted that this criticism has considerable weight, at the present time, against various intelligence tests and trade tests; and judges, who comprise the most conservative class of individuals in the world, are considerably prejudiced against all psychological procedures on this account. The same difficulty has been encountered by J. H. Wigmore, Esq., eminent authority on Evidence, and other revisers of legal procedure, in attempting to introduce various psychiatric tests into the courts. In the case of Deception Tests, the writer, who may share somewhat the chronic conservatism of bench and bar, believes that all complicating psycho-physiological variables should be simplified in the laboratory, and studied quantitatively, before giving the

tests to non-expert users to play with. The research reported below represents the first step toward such a simplification and quantitative study.

2. Problem and Method

The Systolic Blood Pressure Deception Test, in application by the writer since its discovery in 1913, has a total rating of over 95 per cent. in producing correct judgments of truth or deception. Few psychological tests, if any, can show as high an index of efficiency; but for that very reason, in the opinion of the writer, it becomes the more imperative to analyze out the range of psycho-physiological variables not attributable to deception proper. That considerable blood pressure variation occurs, in subjects of both sexes, during mental activities other than the deception itself, is evidenced by the results presented in Tables 1–3. These tables, though presented here to illustrate the problems of analysis confronting the applied Deception Test investigator, have some interest in themselves in that they record an analysis of results obtained in laboratory tests performed at the beginning of War work under conditions dictated by the National Research Council, for the purpose of determining the value of various types of Deception Tests with all personal factors eliminated. Weekly series of tests, ten subjects to the series, were carried on for three successive weeks. Only the cross-examination of subjects was conducted by the writer, the 'crimes' being prepared by Dr. Leonard T. Troland, and the blood pressure recorded by Dr. Harold E. Burtt, who also took the measurements for the reaction-time and breathing tests. Dr. Burtt was separated from the subject by a curtain through which the subject's arm was thrust, so that no facial expressions might unconsciously influence the operator. All records were then marked in code before being given to the writer for judgment. Dr. Troland received both the final judgments from the writer, and the sealed code-key from Dr. Burtt for the purpose of scoring the correctness of the judgments, Dr. Troland having kept his own record, independently, of the choice each subject made between 'crime' and

TABLE I.

HARVARD LABORATORY DECEPTION TESTS FOR NATIONAL RESEARCH COUNCIL (FIRST WEEK)

Code Number of Subject	B.P. Norm + Excitement (Estimated from Entire Curve)	Blood Pressure Behavior							Judgment of Experimenter	Correct Judgment (Recorded by Dr. Troland)
		B.P. Questions				Association Test	Breathing Questions			
		Irrelevant		Crucial			Irrelevant	Crucial		
		Behavior During Reading	Maximum Rise	Behavior During Reading	Maximum Rise	Maximum Rise (from Level at Beginning of Association Test)	Maximum Rise	Maximum Rise (from Level at Beginning of Crucial Questions)		
2964	126	+ 8	12	− 2	22	(−16), then +12	+8 (124 to 132)	− 6	L.	L.
8352	116	+10	22	−12	22	(−18), then +12	−10, then (122−112)	+10 (then −10)	L.	L.
8176	136	+ 2	8	− 2	20	+4 (then −10)	+8 (134 to 142)	−12	L.	L.
4748	130	+2 and −2	6	− 2	18	−10 (+4, −8+2)	+6 (122 to 128)	−18	L.	L.
4812	104	+10 and −8	12	−6, then +6	16	(−6), then +16	+28 (100 to 128)	−18	L.	L.
6324	132	+ 4	14	− 2	14	−2	+8 (124 to 132)	−10	T. and L.	T.
6804	102	+ 2	(2 estimated) (Record uncertain)	Record uncertain	12	−6 (+2−4)	+2 (96 to 98)	+ 2	T.	T.
2936	110	+ 4	0	+ 2	8	+6 (−4, +4)	+6 (108 to 114)	− 6	T.	T.
4488	118	− 4	6	− 6	8	+10 (−14, +6, −10)	−10 (118−108)	− 4	T.	T.
6792	114	+ 2	−4	+ 6	6	+14 (18, +10, −4)	−6 (116−110)	− 8	T.	T.

TABLE 2

HARVARD LABORATORY DECEPTION TESTS FOR NATIONAL RESEARCH COUNCIL (THIRD WEEK)

Code Number of Subject	B.P. Norm + Excitement (Estimated from Entire Curve)	Blood Pressure Behavior								Judgments	
		B.P. Recitals				Association Test	Cross-Exam.	Breathing Questions		of Experimenter	Correct (Recorded by Dr. Troland)
		Irrelevant		Crucial				Irrelevant	Crucial		
		Behavior While Thinking Up Recital	Maximum Rise	Behavior While Thinking Up Recital	Maximum Rise	Maximum Rise (from Level at Beginning of Ass. Test)	Maximum Rise	Maximum Rise	Maximum Rise (from Level at Beginning of Cr. Breathing Questions)		
6913	110	+ 8	28	−10	28	+4, then −14	12	−10	2 (106 to 108)	L.	T.
8301	110	− 2	8	+ 6	16	−4	10	+18 (to 102) (but only 96 to 102 certain)	−36 (120−84) (but record uncertain)	L.	L.
8475	120	no change	16	− 2	16	+4, then −10	6 (or 16) (110 to 126)	− 6	no change (120)	L. (with really a T. story)	L.
2727	110	− 4	28	− 4	28	+2, −8, +12	16 (or 26) (100 to 126)	+2, −12	6 (110 to 116)	L. (with some T. elements in story)	L.
6157	100	− 2	10	− 4	6	+12, then −16	22 (or 26) (96 to 122)	+ 2	−6 (108 to 102)	L.+T. (with (L. in cross exam.)	L.
4637	100	−10	16	− 8	12	−4, then +2	12	+10	−16 (110−94)	T.+L. (L. in cross exam.)	T.
4381	104	no change	4	no change	8	−6	10	+ 6	−10 (110 −100)	T.	L.
2567	126	+ 8	14	− 6	14	+6, then −10	0	+ 2	4 (115 to 119)	T.+L. (L. in Cr. b.p. but T. in cross-exam.)	T.
6543	120	−16 then +12	0	no change	−8	−16	16 (90 to 106)	+ 4	−6 (100−94)	T. (possible L. in cross-exam.)	T.
8493	120	record uncertain	2	− 4	−4	−6, +2, −10	8 (96 to 102)	− 4	8 (92 to 100)	T.	T.

TABLE 3

HARVARD LABORATORY DECEPTION TESTS FOR NATIONAL RESEARCH COUNCIL (SECOND WEEK)

Code Number of Subject	B.P. Norm + Excitement (Estimated from Entire Curve)	Blood Pressure Behavior							Judgments	
		B.P. Recitals				Association Test	Cross-Exam.	Breathing Questions	of Experimenter	Correct (Recorded by Dr. Troland)
		Irrelevant		Crucial						
		Behavior During Planning	Maximum Rise	Behavior During Planning	Maximum Rise	Maximum Rise (from Level at Beginning of Ass. Test)	Maximum Rise	Maximum Rise		
9534	120	−16	8	+ 8	26	+2, −8	20 (or 28) (112 to 140)	+18, −26	L.	L.
3424	120	no change	24	+ 6	24	+10, −18, +2	14 (or 18) (116 to 134)	−6	L.	L.
3594	120	no change	10	+ 6	20	−4, +2, −6	8 (or 14) (114 to 128)	record uncertain	L.	L.
9766	130	+ 2	14	+ 4	20	−4, −6, +4	10	−10	L.	L.
7658	120	−10	14	− 8	14 (but 18 at very start)	+10, −12, +4	14	−10 (uncertain) +4	L. (guilty, but told T. story mostly)	L.
1212	116	−14	0	+ 2	8 (with 2 min. peak of 20)	+2 (116 to 118), −6, +8	0 (or 2) (114 to 116)	−4	T. (some L. in Cr. b.p. recital)	T.
7974A	130	− 2	8	+12	8	4 (130 to 134)	2	−6, +6, −4	T.	T.
5346	130	+ 8	4	− 4	−6	4 (130 to 134)	6	−8	T.	T.
1206	126	− 2	−2	+ 5	4	2 (122 to 124)	−2	−4, +4	T.	T.
5882	122	−2, +2	0	− 4	2	4 (118 to 122)	−4	−4	T.	T.

'innocence.' No one of the three experimenters, therefore, could know whether the judgments that were being made were correct or incorrect until the entire three weeks' tests were completed; and no experimenter could, therefore, be influenced in conducting his part of the examination by knowledge of how any other part was succeeding. Before the code key was opened, the writer informed Dr. Troland of his decision to throw out the entire second week's results, since it was evident from the records that the subjects had disobeyed instructions, mixing truth and falsehood in such a way as to produce no clear consciousness of either, under the laboratory conditions obtaining. Judgments were turned in, however, and proved to be 80 per cent. correct. It also turned out that the subjects on whose records the errors were made had confused the conditions as detected by the writer from inspection of their records. The blood pressure judgments for the first and third weeks were 100 per cent. correct. Breathing and reaction-time test judgments proved only 50 per cent. and 60 per cent. correct, respectively.

It will be noted from a glance at the above tables that blood pressure variations running between the extremes of minus 16 and plus 28 occurred during irrelevant 'blood pressure' and 'breathing' questions.[1] The problem, then, arises, to what extent shall we attribute these variations to the carrying over of deceptive consciousness into matter irrelevant to deception proper, and to what extent must we expect to find such changes occurring merely as resultants of mental states common both to truth and to deception? In order to answer this question, it would seem to be necessary to eliminate the deceptive element from our test conditions (although it must be realized that in so doing a material alteration may be made in the very constituent elements we are attempting to study by simplification); and then to make a sufficient number of measurements to discover the probable average variations as well as possible range of variation, for the various types of subjects with whom the deception tester may be called upon to

[1] Attention is also called to the marked b.p. variations which occurred during the association reaction-time tests. This element has been made the subject of an extended individual study, results of which will subsequently be reported.

deal. One of the most obvious classifications of subject types is that based upon sex. In our previous laboratory and applied work with the tests, sufficient evidence of possible differences between the blood pressure behavior of men and women had appeared to render such a study advisable. The following research, therefore, sought to examine both sex characteristics of blood pressure behavior, and normal range of blood pressure changes in both sexes during mental states constituent of deception but not characteristic of it.

The five commonest conditions entering into b.p. Deception Tests are:

1. Quiet.
2. Reading irrelevant matter introduced to establish norm plus excitement.
3. Conversation on subjects irrelevant to test.
4. Narration of facts learned from others, from observing actions of others, and from memories of own actions.
5. Cross examination based upon such narration.

Eliminating the issue of deception, therefore, (in every series except Series *M*) we attempted a rough determination of blood pressure variations and sex characteristics during different applications of these five conditions. Since the experimenter believed that single unified series of quiet, reading, conversation, narration, or cross-examination might produce certain marked sets in the subject's attitude, and thus introduce a further complicating factor, the various series were intermixed irregularly, in such a way that the subjects not only had no preconceived idea of what the conditions of the experiment each week were to be, but also had no idea even at the end of the experiment that the different series had any connection, or actually constituted unified groups.

No attempt at artificial control of the subject's mental states was made in any of the series other than that obtaining under ordinary test conditions, the experimenter striving to concentrate the subject's attention on the subject-matter in hand as in any test, eliminating the introspective attitude as much as possible since this attitude would necessarily intro-

duce an element not present in a Deception Test. In further pursuit of this purpose such introspection as was required was elicited somewhat after the manner of psycho-analysis; that is, without allowing the subject to become aware that introspection was being obtained. A very familiar and friendly relation between the experimenter and his subjects facilitated the accomplishment of this result, making it easy to bring out clearly the subject's attitude and report of conditions in a joking way, or by means of spontaneous remarks to which the experimenter apparently paid no attention, but which he subsequently noted on the records. In short, our chief effort was to reproduce the various natural conditions just as they exist in the deception test itself, with only that as yet problematical change in general setting due to the elimination of deception. If any extraneous or additional elements should be admitted we must fail in our attempted analysis by simplification. Moreover the writer wishes again to emphasize the fact that all five groups of conditions studied here are still psychologically complicated to a high degree, and must, therefore, in future studies, be further simplified by the gradual elimination of one element after another until we are able to discover the psycho-physiological expression, if any, of each component element.

The research here recorded was carried on in the Harvard Laboratory during the years 1919–21, with the direction and coöperation of Dr. H. S. Langfeld, Mrs. E. H. Marston, and Miss M. V. Kennedy, supplemented by subsequent work by the writer for the purpose of further analytical interpretation of initial results. A total of ten men and ten women subjects participated in the experiment, all students of advanced psychological training. The blood pressure was taken with a Tycos sphygmomanometer, adjusted over the left brachial artery; and readings were made by the use of a bracelet stethoscope, at the rate of about one a minute. Blood pressure operators were changed with regard to the sex factor as recorded under each group of results following.

3. Results

Group I. Quiet

In every Deception Test a period of quiet is introduced at one or more points in order to help in determining the norm plus excitement. These periods usually occur at the beginning and end of the test. The subject, of course, in an actual deception test, does not know the nature of the test to which he is to be subjected, although he naturally suspects it will have some bearing on the crime, or deception, of which he is being accused. At the end of the test, however, he does know that the ordeal is over, and that he merely has to remain quiet during a few last readings before he is released from the apparatus. These two conditions, respectively, *i.e.*, before and after an unknown test, were reproduced in Series *A* and *B* of Group I. The intervening 'test,' however, in these series, consisted merely of conversation; so that no such contrast was to be expected between the b.p. level during the conversation and the b.p. level during quiet following the conversation as appears in applied Deception Tests, since, in fact, such contrast was just what we wished to eliminate in our present study. The simple conditions we wish to investigate remain, however; *i.e.*, quiet before an unknown test, and quiet after some 40 minutes activity when the subject knows he is about to be released from the experiment. Series *C* of Group I. was a further variation introduced to study the blood pressure behavior during an extended period of quiet, external sense stimuli excluded, when the subject was under no instruction or control whatever with regard to his mental content. This condition was intended as a further simplification of both Series *A* and Series *B*; since it eliminated the 'before' and 'after' elements. (All blood pressure changes recorded in the tables below are expressed in millimeters of mercury, the ordinary sphygmomanometer unit.)

Table 4 above shows a summary and analysis of Series *A–C*, Group I. It will be noted that the average blood pressure change per reading for women is between 2 and 3 times that for men. The average maximum b.p. change for

women is about twice that for men, and the average minimum b.p. change for women is between $1\frac{2}{3}$ and 4 times that for men.

TABLE 4

GROUP I.—QUIET

Series	A		B		C	
Conditions	Before Conversation		After Conversation		No Conversation Eyes Covered	
Sex	M.	F.	M.	F.	M.	F.
Average *b.p. change* per reading	$2\frac{1}{2}$	7	2	4	2	$5\frac{5}{6}$
Average *maximum b.p.* change between readings per record	4	$8\frac{3}{5}$	$3\frac{1}{2}$	$7\frac{1}{2}$	$6\frac{6}{7}$	$15\frac{1}{3}$
Average *minimum b.p.* change between readings per record	1	4	0	$2\frac{1}{2}$	0	$1\frac{2}{3}$
Average no. of minimum b.p. changes between readings per record	2	1	2	1	$5\frac{1}{7}$	$4\frac{1}{6}$
Average *maximum total* b.p. rise per record	5	$12\frac{2}{5}$	4	9	11	$18\frac{2}{3}$
Greatest maximum total b.p. rise of series	8	20	6	14	16	24
Smallest maximum total b.p. rise of series	4	8	2	6	6	14

It also seems of interest to note the average number of minimum b.p. changes between readings per record for the two sexes. This measurement, however, is a much more significant one in some series than in others. When taken in connection with the average minimum change between readings, the point is brought out that the male pressure records contain a much greater proportion of negligibly small changes between readings than do the women's records. The average maximum b.p. rise per record gives the actual average range of variability to be expected in the normal records of the respective sexes under the conditions studied, and about the same ratio, 1 to 2, between men and women subjects, appears for this measurement as for those mentioned above, throughout this group of records. The maximum total b.p. rise per record also is a measurement which is of interest in an actual Deception Test whenever it becomes difficult to determine the true norm plus excitement for the day, since the maximum total rise must then be given weight in making a judgment as to whether or not the record is indicative of deception. The

result of this study would seem to indicate that about half as much weight can be given to this measurement in the case of women as can be given with men.

The last two measurements recorded in Table 4, namely the greatest and smallest maximum total b.p. rise of each series give us the absolute range of variability in a normal record for the two sexes. Thus we see that, in Group I., the total absolute range of maximum b.p. rise for women lies between 24 and 6 mm., while for men the range is from 14 to 2 mm. It may further be noted that the absolute range of variation is considerably greater for both sexes during prolonged and uncontrolled quiet, found in Series *C*, than during the shorter quiet periods, found in Series *A* and *B*. Series *A*, moreover, shows a somewhat greater range of variability with both sexes than does Series *B*. This difference is doubtless enhanced, in actual Deception Tests, since the anticipated test must lend considerably more affective excitement to the preceeding period of quiet than would any anticipated experiment in the laboratory. The differences shown in Table 4, then, appear accurately to reflect the nature of the differences to be found in applied tests, though on that smaller scale to be expected in a laboratory environment. The results under Group I. seem to indicate, unequivocally, that female blood pressure is very much more variable under conditions of uncontrolled quiet than is male blood pressure.

Group II. Reading

In applied Deception Tests it very often becomes necessary to place certain reading matter before the subject for the purpose of confronting him with certain evidence, or in order that he may be asked concerning his knowledge or information supplementary to a given document or memorandum. Such reading, however, is so closely bound up with the crucial cross-examination of a witness that it probably would be futile to attempt to divorce the deception element from other activity. On the other hand, perhaps the greatest difficulty of all, in applied Deception Tests, is the determination of the day's norm plus excitement, and to assist in this de-

termination the writer has frequently introduced various types of irrelevant reading matter into the Deception Test by way of contrast to the crucial subject of the test itself. The purpose of this Group, therefore, was to discover the range of variability and sex characteristics, if any, in the normal blood pressure behavior during different types of reading.

TABLE 5

GROUP II.—READING

Series	*D*		*E*		*F*	
Conditions	Short Story (Not Previously Read)		Psychological Text Book (Not Previously Read)		Morning Newspaper (Not Previously Read)	
Sex	M.	F.	M.	F.	M.	F.
Average b.p. change per reading	3	5	2	7	2	7
Average maximum b.p. change between readings per record	6	6	5	11	3	18
Average minimum b.p. change between readings per record	0	2	0	1⅓	0	1
Average number of minimum b.p. changes between readings per record	3	3	4	2	2	1
Average maximum total b.p. rise per record	9	15	8	13⅔	5⅓	19⅓
Greatest maximum total b.p. rise of series	16	26	14	18	8	28
Smallest maximum total b.p. rise of series	6	6	2	8	4	14

In Series *D*, a short story requiring about 35 minutes reading was selected. A story was chosen which would arouse only a moderate amount of sustained interest on the part of the subject, since, of course, in an applied Deception Test, the interest of the subject in any story presented to him would be considerably dampened and reduced by the ordeal of the real test which he was primarily concerned with. During this series the sex differences in average b.p. change per reading, and average maximum b.p. change between readings were less marked than in any other series. The maximum total b.p. rise per record, however, shows a considerably greater average b.p. variation on the part of the women subjects than on that of the men. The results of Series *D*

show, on the whole, that exactly that condition of concentration on the subject-matter comparable to the applied test was obtained. It would seem that subjects of both sexes were sufficiently interested in the story to exclude emotional stimuli extraneous thereto from consciousness, since no very marked b.p. changes appear; and from that same fact we may conclude that no emotional elements were contained within the story itself sufficient to cause great blood pressure variability.

We then pass to Series *E*, which consisted of the recording of b.p. behavior during the reading of a very difficult passage in a psychological text-book not previously read by any of the subjects. Here practically the same ratios between the b.p. changes of men and women subjects again appear as were found in Group I. From the subjects' general reports and observations it would seem probable that the passage to be read contained so little interest, and at the same time required so high a degree of concentration in order to be understood, that certainly the female subjects, and probably to a lesser degree the male subjects, also, failed to attain a sufficient degree of concentration to exclude extraneous conscious elements.

Similarly in Series *F*, where a morning newspaper not previously read was perused by the subjects without any restriction as to what part of the paper should be read, the interest in the reading was so casual and intermittent (again especially in the case of the women subjects) that many extraneous ideas and associations appeared in consciousness.

Probably the contrast, in Series *F*, between the men and women subjects is not a fair one, since the men subjects were found to take a great deal more interest in the daily paper than did the women. The men, therefore, may be supposed to have attained a degree of concentration of attention equal to that reached in Series *D*, whereas the attention of the women was only focussed on the newspaper contents to a very slight degree, and hence fluctuated rapidly between newspaper headlines and the various emotional associations within their own minds set off by these headlines. Neverthe-

less, Series *F* is of value in definitely eliminating the possibility of using newspaper reading as a comparable criterion for the determination of the day's norm plus excitement in the case of either men or women subjects. The total absolute range of maximum b.p. variability in this series was found to be somewhat greater for the women than in Group I., the range in Group II. being between 28 and 8 mm. as against 24 and 6 in Group I. The range of variability for the men, however, in Group II. was between 16 and 2 mm., which is almost identical with that in Group I. The comparison of these two groups might give rise to the suggestion that, with men subjects, practically the same proportion of emotion was admitted to consciousness during reading as during quiet; whereas with women subjects, more emotional associations were set off by the stimuli furnished in reading matter (at least when this consists of fiction or news), than when external sense stimuli were entirely cut off.

Group III. Conversation

Group III. is concerned, primarily, with the investigation of b.p. variability and sex characteristics during ordinary conversation on topics to which the interests of the subject

TABLE 6

GROUP III. CONVERSATION

Series	*G*		*H*		*I*	
Conditions	With Person of Opposite Sex, Met for First Time		With Experimenter of Opposite Sex Met for First Time		With Experimenter, After 6 Weeks Acquaintance	
Sex	Men	Women	Men	Women	Men	Women
Average b.p. change per reading	$3\frac{1}{6}$	$7\frac{1}{2}$	$2\frac{1}{2}$	4	$2\frac{2}{3}$	$8\frac{5}{6}$
Average maximum b.p. change between readings per record	$9\frac{2}{3}$	$20\frac{2}{3}$	6	$8\frac{2}{3}$	$7\frac{1}{3}$	$18\frac{1}{3}$
Average min. b.p. change between readings per record	0	$1\frac{5}{6}$	0	0	0	$1\frac{1}{3}$
Average number of minimum b.p. changes between readings per record	$5\frac{5}{6}$	3	3	1	5	$1\frac{5}{6}$
Average max. total b.p. rise per record	$13\frac{2}{3}$	$28\frac{1}{3}$	$9\frac{2}{3}$	14	$10\frac{1}{3}$	$25\frac{2}{3}$
Greatest maximum total b.p. rise of series	16	32	16	22	20	46
Smallest maximum total b.p. rise of series	10	26	4	8	4	16

naturally lead. In addition, however, the problem of the effect of sex difference between subject and experimenter, which might be cited as a complicating element both in laboratory b.p. researches and in applied Deception Tests, was investigated. If sex difference between subject and experimenter should prove to be a factor of such weight that the results sought in the experiment might be confused thereby, the added precaution of using a female b.p. operator and examiner for all female subjects would be indicated.

As with practically all the other conditions studied, the sex element in ordinary conversation was found to have a very much greater effect upon the women subjects than upon the men. The differences, however, appear very much more marked in the case of a purely social meeting for the first time with a person of opposite sex (recorded in Series *G*), than in the case of ordinary conversation with an experimenter of opposite sex met for the first time, (shown in Series *H*). Curiously enough the male subjects proved more susceptible to an operator of opposite sex when such operator was introduced unexpectedly and casually, during occasional check records in later series, than were women under similar conditions. The explanation of this fact probably lies in the same factor as that behind men's greater susceptibility to a woman met for the first time conversationally, than to a woman under the same conditions after a considerable acquaintance has been formed, and will be considered later, when this latter result is discussed.

Series *I* shows the differences in b.p. variability of men and women subjects in conversation with the writer, acting as experimenter, after six weeks acquaintance. It is probable that the sex difference in stimulus is a complicating factor here in the case of women subjects, since the sex influence seems to be more potent, with women subjects, after a familiar relationship has been established with a member of the opposite sex than when the man in question is a total stranger. This is exactly the converse of the result obtained for men subjects, as mentioned in the preceeding paragraph.

On the other hand, it appears to be a fact that propor-

tionally greater variability appears in the blood pressure of men subjects during a conversation with a male operator after a considerable degree of intimacy has been established than was noted during the initial conversation. An explanation of this fact may lie in the added affective interest which a man usually takes in conversation with a male friend whom he knows well enough to exchange serious views and opinions, as contrasted with a conversation filled with trivialities as usually happens between men meeting for the first time, the natural male reserve on either side not yet having been broken down. Taking this latter element into consideration, we may believe that Series *I* presents a somewhat fairer comparison than might be believed at first glance, since more emotional elements may be expected to enter into the conversation in the cases of both men and women subjects than were present during the first record taken by a hitherto unknown operator of opposite sex. For this reason, Series *I* was planned to contrast b.p. behavior during conversations of men and women subjects with a male experimenter (the writer), after six weeks acquaintance, rather than to contrast b.p. changes during conversation with an experimenter of opposite sex after the same period of acquaintanceship; although the latter would have been quite as feasible under the conditions of the experiment, and would seem, perhaps, to have been the logical sequel to Series *H*, which consisted of a conversation with an experimenter of opposite sex met for the first time.

The total absolute range of maximum b.p. variability was found to be exceptionally great in subjects of both sexes in this group, ranging between 46 and 8 for women, and between 20 and 4 for men. The natural conclusion from this very wide range of variability seems to be that casual conversation on subjects irrelevant to the principal issue of a Deception Test is of very little value, if any, in determining the day's norm plus excitement. Moreover, especially with women subjects in the applied tests, this wide range of variability shows that great care must be used, even in the crucial examination itself, in correlating the rises upon which the judgment of guilty or innocent is to be based very closely

with subject-matter unquestionably relevant to the main issue of truth or deception. In short, if a conversation upon points irrelevant to any crime or deception can produce a rise of 46 mm. in the blood pressure of a woman subject, we must be exceedingly careful to make sure that b.p. rises which are regarded as crucial, in applied Deception Tests, are not actually caused by emotional associations with the subject matter of the examination which may have no relevancy whatever to the principal issue. It may be said, however, in mitigation of this seemingly insuperable complication, that the intense concentration in the cases of men or women accused of crime, or whose testimony has been made an object of suspicion, tends to exclude those chance emotional associations which might otherwise cause large b.p. fluctuations in the course of testimony or cross-examination. Nevertheless with this very large normal range of fluctuation before us, we cannot proceed otherwise than with the utmost caution in our interpretation of applied Deception Test curves.

Group IV. Narration

In applied Deception Tests, free narration of that to which the subject was a witness, or of facts which have come to the subject's knowledge through reading documents or letters, or which have been told the subject by others; and especially narration of the subject's own actions during a specified period of time, all constitute a crucial subject-matter of the test only second in importance to the cross-examination of the subject based upon this freely told story. This group studies, therefore, these types of narration.

In Series *J*, the subjects were asked to narrate, from memory, any story read two weeks or more before the experiment. This condition seemed fairly comparable to the narration by witnesses of facts learned by them at second hand, either from reading or from information from others. There remained, in the laboratory experiment, something of the same interest on the part of the subject in giving an accurate account of the story in question as obtains in the case of a witness called to testify in a criminal case in which he is not

TABLE 7

GROUP IV. NARRATION

Series	*J*		*K*		*L*		*M*	
Conditions	Telling Story Read 2 Weeks Before		Telling Most Exciting Incident of Week		Telling Own Actions During Last 24 Hours		Option of Telling True or False Account of Own Actions	
Sex	M.	F.	M.	F.	M.	F.	M.	F.
Average b.p. change per reading	3	5⅓	3	6	2	7	2	4⅔
Average maximum b.p. change between readings per record	4⅔	9⅓	6	14	5	15⅓	6⅔	5
Average minimum b.p. change between readings per record	0	1⅓	0	1⅔	0	1⅔	0	2
Average no. of minimum b.p. changes between readings per record	2⅓	1⅔	2	2	3	2	2⅔	1⅓
Average maximum total b.p. rise per record	6⅔	15⅓	8⅘	20⅓	6	24⅓	7⅓	17⅓
Greatest maximum total b.p. rise of series	12	20	12	26	10	48	12	26
Smallest maximum total b.p. rise of series	4	12	6	12	4	16	2	12

the defendant; although, as in the other series of our laboratory investigation, the element of possible deception was eliminated. The total absolute range of women's b.p. variability as compared to that of the men was found to be, as in preceding series, in the proportion of about 2 to 1.

Series *K* was designed to reproduce the fundamental conditions of a story told by a witness, possibly to the prosecuting attorney, soon after the occurrence of an incident under investigation; and also was planned to include the element of 'excitement' which any incident connected with a criminal case is apt to contain. The relation in this series between the b.p. variability of men and women subjects remains in about the same ratio as in previous series, although it is to be noted that the absolute range of variability in the case of the women was somewhat increased.

In Series *L*, we pass from the examination of a witness to the case of a suspected defendant who is narrating his own actions during the period of time under investigation. The elimination of suspicion of criminal guilt tremendously alters

the condition, of course, but by means of choosing periods of subject's actions that could be checked up, and rating each subject upon the accuracy and completeness of his testimony, a considerable degree of interest and effort was induced, both with men and women subjects, in giving a satisfactory account of their own actions. It is of interest to note that the ratio between the total absolute range of maximum b.p. variability is here considerably altered as between the sexes, showing the ratio increased to between 3 to 1 and 4 to 1, with women on the long end, as before. This result would seem, on closer examination of the individual records, to have been produced more by the reduction of the male averages than by increase of the female, although some increase in the total range of b.p. variability is noticeable with the women subjects in this series. When this increased difference between the sexes, in this series, began to appear, it seemed probable to the experimenter that its cause might lie in feminine embarrassment at being called upon to narrate personal actions to an experimenter of the opposite sex; and, in order to check this point, a woman operator conducted the balance of the series with both men and women subjects. No change in results could be detected, however.

Finally, in Series *M*, we introduced for the first and only time the element of possible truth or deception in narration of subject's own actions during a specified period of time, for the purpose of determining whether deception might possibly change the whole setting, even though nothing hung on the success or failure of the story. The deceptive element was treated with indifference by the operator, as far as possible, so that only the additional mental *task* remained. 60 per cent. of the women, and 40 per cent. of the men chose to lie concerning their actions, apparently for no other reason than a slight added interest in fabricating an original story. The ratio between the sexes, however, notwithstanding the greater proportion of 'deceptions' on the part of the women, fell back to about 2 to 1, the total absolute range of maximum b.p. variability falling back 25 to 40 per cent. from Series *L*. It is evident, therefore, that no indication of increase of b.p.

variability due to the mere possibility of choosing to deceive, in itself, was discovered. The results on this point as shown by detailed comparison of Series *M* and *L* seem wholely negative. The probable explanation of the general decrease in absolute range of variability in Series *M* seems to lie in the fact that the subjects had been called upon once, some weeks previous, to give an account of their own actions during a specified period (Series *L*), so that a repetition of this instruction, even though accompanied by the possibility of deception, failed to arouse the subject's interest and was regarded merely as a more or less monotonously difficult task. In considering the comparisons of these series, it should constantly be remembered that the series in each group did not follow one another during successive weeks, but were interspersed in such a way that no direct comparison between two similar sets of conditions was possible on the part of the subjects. The need of this precaution is evident if, as the subjects' behavior indicated, a very vague memory of Series *L* served, after several weeks' interval, to produce lack of interest in Series *M*.

Group IV., as a whole, shows about the same absolute range of b.p. variability as did Group III.; *i.e.*, 48 to 12 mm. for women, and 12 to 2 mm. for the men.

Group V. Cross-Examination

Having arrived at the most crucial condition of the applied Deception Test, namely, cross-examination, we find the rather unexpected result that the b.p. variability is considerably *less*, with both sexes, than in the preceding groups. The cross-examinations in Group V. were based upon narrations exactly similar to those contained in Groups I.–IV.; the subjects being informed, however, that they would be cross-examined upon their stories, since witnesses are fully aware that they will be questioned in detail concerning the facts to which they testify during direct examination, or which are contained in their own voluntary stories. Cross-examinations were conducted by the writer in a serious fashion, and with as lawyer-like a manner as possible. Subjects were pressed upon

points of seeming contradiction, and were harassed with considerable persistency concerning their memory of details which they claimed to have forgotten.

TABLE 8

GROUP V. CROSS-EXAMINATION

Series	*N*		*O*		*P*		*Q*	
Conditions	On Story Read Previous to Experiment		On Narration of Most Exciting Incident of Past Week		On Narration of Action During Last Half-Hour		On Narration of Action During Last Half Day	
Sex	Men	Women	Men	Women	Men	Women	Men	Women
Average b.p. change per reading	2	6½	3⅓	7	2	6⅜	3	6¼
Average maximum b.p. change between readings per record	3⅓	10	5⅜	11½	4⅔	10⅜	8	15
Average minimum b.p. change between readings per record	0	3	0	2	0	3⅓	0	1
Average no. of minimum b.p. changes between readings per record	3	3	1⅜	1⅜	1⅔	1⅜	3	1¼
Average maximum total b.p. rise per record	6⅔	13½	6⅜	16½	4⅔	15⅜	12	28½
Greatest maximum total b.p. rise of series	8	18	12	24	14	18	12	42
Smallest maximum total b.p. rise of series	6	12	2	10	2	10	12	16

The best efforts of the writer, in Series *N* (a cross-examination upon previously read story), failed to produce a total absolute range of maximum b.p. variability greater than 8–6 mm. for the men, and 18–12 mm. for the women. In Series *O* (a cross-examination upon the story of the most exciting incident of the past week), this total absolute range of maximum b.p. variability was increased to 12–2 mm. for the men, and 24–10 mm. for the women subjects. In Series *P* (cross-examination on subject's account of his own actions during the last half hour, on which an objective check was available), the women's total absolute range of maximum b.p. variability fell back to 18–10 mm., while that of the men remained the same as in Series *O*, that is, 12–2 mm. In the last series of this group, Series Q, a very sharp cross-examination was conducted by the experimenter on the subject's

story of his own actions during the half day preceding the experiment (only partial objective check available), with a resulting increase in the women's total absolute range of maximum b.p. variability to 42–16 mm., while with the men subjects, the curious result of a uniform b.p. maximum rise of just 12 mm. was obtained.

Throughout Group V., practically the same ratio between b.p. variability of men and women subjects was found as in preceding groups; although as above recorded, the total averages were considerably lower for both sexes than in Groups I.–IV. In Group V., then, we find the most marked effect of the total elimination of the deceptive element, since the b.p. curve symptomatic of deception reaches its height during cross-examination in applied Deception Tests, and this portion of the record constitutes, therefore, the crux of the whole test, and is the measurement upon which the judgment of guilt or innocence is, in the last analysis, based. This result would appear to be most favorable to the introduction of the b.p. Deception Test into legal procedure, since, although the sex differences in b.p. variability still exist, large total maximum b.p. rises during cross-examination may apparently be attributed less to complicating factors outside deception proper than is the case during less important parts of the Deception Test; with the strong probability that practically all such complicating factors, other than deception, which existed in the laboratory, would be excluded by the rigid setting of attention during an important applied test. Except for the single b.p. rise of a woman, in Series *Q*, the range of normal variability for both sexes, averaged, lies around 15 mm. or below, with 24 mm. (female), and 14 mm. (male) as the high extremes. This result, if even approximated in a sufficiently large number of measurements, would seem to leave a very satisfactory margin of safety in the interpretation of the records, when the form of the curve during cross-examination, and the correlation between b.p. behavior and subjects' testimony reported stenographically are taken into consideration.

Summary, Groups I.–V

TABLE 9

TOTAL AVERAGES OF ALL 5 GROUPS

Laboratory Subjects

(No question of Guilt or Deception)

	Men	Women
Av. b.p. change per reading	2.4	6.2
Av. maximum b.p. change between readings per record	5.6	12.
Av. minimum b.p. change between readings per record	0	1.9
Av. no. of minimum b.p. changes between readings per record	3.05+	1.8
Av. maximum total b.p. rise per record	7.9	18.1
Av. greatest maximum total b.p. rise of series	12.4	26.5
Av. smallest maximum total b.p. rise of series	4.7	12.1

Table 9 shows the total averages of the five groups; comprising, in all, fourteen completed series with male and female subjects, and including, approximately, six thousand individual measurements. These total averages are of interest in that they seem to indicate, throughout a considerable number of records, a clear difference between the average variability, and range of variability, of male and female blood pressure, under conditions not only common to Deception Tests, but also most usual and frequent in every-day life. The writer does not believe that the utmost range of variability has been discovered, by any means, for *all* ordinary daily activities; but he does believe that the subjects tested for the conditions above described constituted a fair sampling of both sexes with regard to emotional and intellectual types, (both extremes of each being represented for both sexes); and it seems probable that more extensive experimentation would produce results following the general trend, if not the exact ratios, of this introductory research.

4. CONCLUSIONS RELEVANT TO APPLIED DECEPTION TESTS

1. The first practical conclusion to be derived from results showing such marked sex differences in blood pressure behavior is the practical necessity that Deception Tests applied to women subjects must be more carefully controlled than those applied to men; and that the resulting blood pressure

curves be more carefully interpreted, with women subjects, in order to exclude chance variations falling within the range of normal b.p. variability for women.

2. It appears that conversation with the experimenter on matters extraneous to the deception cannot be used as a condition to assist in determining the day's norm plus excitement. Moreover, we have the further result that a considerable range of normal variability is to be expected during reading and irrelevant narration. We must conclude, then, that uncontrolled quiet periods, especially at the close of the examination, furnish the most level form of b.p. curve, with the lowest absolute range of variability, both for men and women subjects. The variability here in the case of men is practically negligible, while that for women, although between 2 and 3 times that of the men, still remains so low that it may be expected not to interfere seriously with our judgment of the day's norm.

3. We may further conclude that the total average b.p. change between readings during narration and cross-examination—the two most important parts of any Deception Test—is not quantitatively sufficient to obscure results. In both narration and cross-examination, male blood pressure shows a total average variation of less than 3 mm.; while female b.p. variability is less than 6 mm. during narration, and only 6.5 mm. during cross-examination. It will be seen by reference to the writer's original report of the b.p. Deception Test [1] that 8 mm. was then fixed as the probable minimum b.p. rise caused by deceptive consciousness, and subsequent applied tests have indicated the advisability of raising that minimum to 12 mm. The average amount of change, then, between readings, for both sexes falls significantly below the minimum increase attributable to deception.

4. Finally, the writer concludes that the total b.p. rise throughout an entire record due to emotional elements other than those concerned with deception may, occasionally, considerably overlap the increment of increase usually symptomatic of deception, if an emotional 'complex' of great

[1] Jour. Exp. Psy., Vol. II., No. 2, April, 1917, pp. 117–163, at p. 130.

strength becomes more vividly present in the subject's consciousness than is the issue of truthfulness or deception in the principal subject-matter under examination. This possibility is clearly indicated by the high extremes of 42 and 48 mm. changes in female b.p. during narration and cross-examination. It may be noted, by reference to the series in question, that the experimenter could by no means assure himself that these extraordinary rises in Series *L* and *Q* (the only changes in excess of 26 mm. in Groups 4 and 5), might not be caused by deception itself, since no sufficiently complete objective check could be obtained on the points in issue. The woman who registered these extreme changes was very emotional, however, and it is quite possible that various affective elements in her mind, connected with the subject matter under discussion, might have produced the b.p. modifications noted. It will be recalled that the writer pointed out, at the beginning of this paper, the possibility that the removal of the deceptive element from experimental conditions might conceivably alter the constituent states studied. It now appears that we find an example of such alteration in the removal of the rather rigid motor setting which is found whenever the subject is intent upon the task of convincing an examiner of his truthfulness. The result of this alteration of the setting is the admission into consciousness of those personal emotional 'complexes,' as noted with the woman subject above, which would probably be excluded by the subject herself were the suggested setting present, as in an actual Deception Test. In short, many more emotions are, in all probability, admitted into the subject's mind when the issue of truth or deception is absent, than when it is present. But since, without further research upon this point, we cannot be certain how large a proportion of emotional elements irrelevant to deception are excluded from the truth-teller's consciousness under any given set of test conditions, our present results suggest the necessary precaution of allowing for the possible extent of the influence of such elements on the b.p. of a female subject in making judgments of truth or deception; especially in cases where the issue of innocence or falsity means little to the

woman undergoing the test. In applied tests with female subjects, the b.p. rises due to deception are usually correspondingly great, so that the final result is a shifting upward of the whole range of relevant and irrelevant variability. (Of course, also, the whole level of the applied test record is lifted 12 to 30 mm. by the 'excitement,' or fear of the mere test itself; and this constant added increment usually obliterates all those individual irrelevant emotional elements which might otherwise express themselves in the record, with the exception of the extreme female modifications here considered.)

5. Suggested Interpretation of Sex Differences in Blood Pressure Behavior

1. If, as the work of W. B. Cannon clearly indicates, all major emotional rises of systolic blood pressure (*i.e.*, over 12 mm.), under ordinary conditions, are caused by fear, anger, or pain, the above-reported results seem to suggest, rather definitely, that female subjects have a much larger amount of fear or anger elements in consciousness (pain being excluded by the conditions), during quiet, reading, conversation, narration, and cross-examination, than do male subjects. Men, in fact, would seem to experience major emotional consciousness only occasionally, under these common conditions, and never as intensively as women.

2. A study of the duration of maximum rises, in the records of both sexes, shows that men's maximum rises are usually extended over many more readings than are women's. Thus it appears that emotions capable of producing major b.p. changes fluctuate within the female consciousness with great facility and rapidity, while any emotional influences that find their way into expression in the male organism tend to persist, and even to build themselves up over a considerable number of readings, followed by still longer periods when no emotional response whatever to the subject-matter under discussion is evident. The writer's interpretation of this emotion-blood-pressure characteristic rests upon an apparent sex difference in the type of the organization of the emotional

responses with regard to the ideational or sense stimuli contained in the subject-matter of ordinary reading, conversation or narration. In the case of female subjects as indicated both by behavior and introspection, practically every sense datum or idea consciously related to the individual's personal interests or activities (and an extremely large percentage of all sensations and ideas seem so related, with women) has an emotional response all its own. After all associative connection between stimulus and interests has ceased, the stimulus seems to retain its emotional response, unimpaired, without reference to elements other than itself. This emotional element is usually sufficient to modify the blood-pressure when first introduced, but like any reflex complete in itself the motor (emotional) expression is purely transitory, and quickly subsides; only to give place to a new response of similar nature when a new emotional stimulus is introduced. And with women, nearly every stimulus seems to have become an emotional one. Men, on the other hand, seem to have minimized the number of emotional responses to both sensory and ideational stimuli, by a process exactly the converse of that used by women to increase emotional responses. Even ideas and sensations consciously associated with personal interests and activities seem to find their motor outlet through non-emotional channels. Inspection of notes on involuntary movements of subjects of both sexes suggest the possibility that a larger proportion of male nerve energy finds motor expression in movements of the skeletal muscles than is the case with female subjects; while from the latter's preponderance of b.p. variability, the inference seems clear that a greater proportion of energy must express itself in visceral changes, largely through the autonomic fibers. If this be true, a male tendency toward continual cutting off of emotional (visceral) responses would be indicated; so that no major emotional elements would be brought into consciousness until the very essence, or core, of the man's strongest interests—such as business, matrimony, career, money, etc.—was touched. Once this occurred, however, the emotional response, though perhaps minimized in intensity even with the most vital in-

terests, would be expected to persist in its control of the motor outlets of the organism for an extended period, on account of the relatively stronger cortical organization of the organism's controlling interests. This is exactly what seems to occur, as evidenced by b.p. behavior, and this is the writer's interpretation of the sex difference manifest.

3. We are further confronted by the problem of determining just *what* emotions cause the major b.p. modifications above considered. After carefully examining the introspective data and verbal responses of the subjects in the principal experiment, the unexpected conclusion was forced upon the writer that anger appeared to be the emotion most characteristic of the women's reactions, while fear characterized the more infrequent emotional activities of the men. This result is exactly contrary to the usual 'common-sense' assumption that women manifest more fear than do men, under ordinary conditions, and that men constitute the 'sterner,' or more-given-to-anger sex. Nevertheless, all aspects of the results obtained during the above-reported research are susceptible of no other interpretation than a denial of the current view.

In the first place, a total of many thousands of b.p. measurements taken by the writer during Deception Tests and other researches of an emotional character indicate, unmistakeably, that b.p. rises due to anger are much shorter and more abrupt than those caused by fear. Practically all the female b.p. rises, as evident from tabulated study of individual records, are very short, and very abrupt. This is the characteristic, in fact, which raises the average variation between readings so much higher with women subjects than with men, and reduces the number of minimum changes per record.

Again, almost all rises resulting from a stimulus to anger are in what the writer designates as the 'middle range' of b.p. modification for that particular individual. That is, suppose the maximum deception rise, above the day's norm plus excitement, is 70 mm.—a not unusual range of variability where the deception is important to the individual. A sudden stimulus to anger during such a record, such as an insulting question or innuendo in cross-examination, or the sudden

assertion that the subject is of disreputable character, will cause a sharp b.p. rise, perhaps, of 30 to 40 mm. over the norm plus excitement level, this rise only lasting during one or two readings. Once more we find the range of maximum female b.p. changes during the present studies closely approximating this 'middle range' for each individual subject; and we find a large percentage (about 83 per cent. in fact) of all female major b.p. rises in these series, falling within a middle range determined for that individual, under the particular conditions obtaining during that day's experiment. This, again, is clearly an anger characteristic of the b.p. behavior.

Let any fear stimulus be introduced, in a Deception Test, and the b.p. starts toward its upper range of variability, say a 60 or 70 mm. rise in the individual undergoing examination. This upper range is reached, however, by a series of rises extending over two, three, or more readings, and tends to remain at the high level for at least two or three readings more. If, on the other hand, the fear response be a slight one, the shape of the ascending b.p. curve is the same, but instead of reaching the upper range of variability, or even rising into the middle range for that individual, the b.p. increase is checked at about 10 or 12 mm. above its previous level, which would constitute, under Deception Test conditions, the lower level of b.p. variability. This latter type of b.p. behavior is exactly that found in the records of the male subjects in the present experiments. The lower range of variability was never exceeded, when determined for each individual subject; and only one or two b.p. rises in all groups failed to follow the typical form of a fear curve. The writer has never found a clear anger stimulus that would produce this type of modification. If anger is present, the b.p. behaves exactly as did the b.p. of the female subjects, recorded above.

Careful analysis of the more intangible and obscure data furnished by verbal responses and introspections (behavioristically obtained where possible), as well as consideration of experimenters' notes on subjects' conduct (based on unaided observation), and analysis of subject-matter with which subjects' attention was engaged during the taking of the b.p.

records, all substantiate the conclusion, based upon b.p. behavior, that anger was the common, or constant element present during female major b.p. changes under the conditions studied; while comparativly mild fear furnished the constant emotional element during the much more infrequent major b.p. rises of the men. Such expressions, during conversation, as "I won't!" "I was so mad I could have killed her!" "She said the awfullest things about me!" etc., were all closely related to sharp, characteristic major b.p. rises of female subjects; whereas "I may not get that teaching job," "I haven't heard from her" (his fiancee on a matter of importance), and discussion of coming preliminary Ph.D. examinations, occurred simultaneously with the most notable of the male subjects' b.p. modifications. (These same topics produced *no* b.p. rise with the women under the conditions of the experiment.) Apparently 'common sense' and literary analysis have underrated the genuineness of the feminine anger behind such remarks as above quoted (probably partly because of the mild tone of voice in which they are usually expressed); while masculine courage would seem, perhaps, to be based more upon a general diminution of emotional responses, than upon some positive emotional state superior to fear.

4. One further sex characteristic of blood pressure behavior, evident in the results of this research though opposite in tendency from the changes tabulated above, requires an attempt at interpretation. Sex-emotion, whenever it could be isolated in the results from complicating emotional elements, produced a distinct *drop* in the systolic level. Here, also, a peculiar and somewhat unexpected difference was apparent in the results for men and women subjects. With the female subjects, casual contact with the opposite sex produced little or no change in the b.p. curve; whereas this same type of contact, with men subjects, produced slight, but fairly well-sustained *rises* of systolic b.p. The explanation of these rises in male pressure was *fear*, in the judgment of the writer; that is, 'embarrassment' at a suddenly altered social stimulus. The rises in themselves, however, were so inconsiderable, both

in number and extent, that they scarcely fell within the range of major b.p. variability, and could, therefore, be disregarded in our original experiments. During the last year, however, the writer has further investigated this sex-emotion reaction with the following results. More intensive stimulation, as it were, with a sexually attractive female 'stimulus' produced short, abrupt *drops* in the systolic b.p. level between 8 and 20 mm. in extent, and between three and thirteen readings in duration. In cases of the longest depressions of the b.p. curve, however, there was no *progressive* downward tendency of the curve, but simply an abrupt drop to a lower level, which was then maintained just as evenly as the original 'norm plus' level.

With female subjects, the most effective sex-stimulus was found to be, not the presence or conversation of a strange man, but sex topics of conversation with a person well known (either male or female without noticeable difference in result), relating to the experience or activities of that particular subject, such as love affairs, rolled stockings, 'parties,' and the 'handsome'ness of certain men. During much of this sort of conversation abrupt anger-rises in b.p. seemed to alternate with just as marked sex-drops, as nearly as the rapid alternations could be interpreted in light of behavior, introspection, and analysis of b.p. modification from day's normal level. On several occasions, however, sustained sex 'complexes' were touched (one or two of the most pronounced being checked up, psycho-analytically), with the result that a *progressive downward* curve was obtained, continuing over many readings, and reaching its climax 20 to 30 mm. below the day's norm plus excitement level. One typical curve of this sort, for instance, was obtained during a discussion of chorus-girls and rolled stockings (a custom recently adopted by the subject and observed by male students), the b.p. dropping 28 mm. during five readings, and returning to a level above its starting-point during the next three readings. There could be no doubt as to the subject's interest in the topic of conversation, and so no probability of the drop being caused by mere emotional inhibition. In another record,

made during the past year, a drop of 45 mm. was recorded, with a female subject, progressing steadily downward over a 20-minute period of clear sex-emotion, starting from a level obtained during a semi-somnolent state. No limit seems to suggest itself, therefore, for the downward modification of female b.p. due to sex-emotion, save the absolute limit of the individual subject's range of b.p. variability. (Of course, in dealing with sex conditions, precautions must always be taken against shifts from sex-emotion to fear, which seem to occur whenever the flow of sex-emotion is wholly cut off, or to anger which seems to supersede sex-emotion whenever the subject encounters opposition in sex expression. Either of these emotions will cause an immediate rise of the systolic b.p. instead of a drop.)

The writer's interpretation, then, of sex differences in b.p. behavior due to sex-emotion would follow the above suggested interpretation for fear and anger changes in so far as women must be judged to have *more* sex-emotion than men, under ordinary conditions, there being a far greater number of adequate stimuli to sex-emotion in the female organism. But, contrary to the fear-anger situation, women's sex-emotion seems to be organized in much larger complexes than is men's. Also, perhaps, we may conclude that the type of stimulus to sex-emotion differs with the sexes; men reacting either with slight fear or with as extensive sex-emotion as they may be capable of to the mere presence and conversation of a member of the opposite sex; while women respond, sexually, with unlimited extensity and duration, to ideas or sensory stimuli related to personal experiences of a sex nature.

5. If we were to go the full length of possible interpretation, then, in summarizing the results presented above, we might say that, under most ordinary conditions, men are habitually unemotional, but possess a few large and fundamental groups of fear responses, closely inwrought with the major interests controlling their activities; and that they are subject to occasional, limited bursts of sex-emotional response, and anger; while women are habitually emotional, with their largest and deepest emotional response patterns composed

largely of sex-emotion elements, frequently shifting to marked anger responses, and occasionally alternating with fear reactions when sex-emotion is definitively interrupted.

The research reported above, together with other systolic b.p. studies of emotional states now in process of preparation for publication, have suggested to the writer the possible value of the method of emotional analysis by means of b.p. fluctuations to the general theory of emotions and affection, as well as to the ultimate determination of the underlying cause of fundamental sex differences that may be found to exist in any psychological field.

THE CARDIO-PNEUMO-PSYCHOGRAM IN DECEPTION

BY J. A. LARSON

FROM THE RESEARCH LABORATORY OF THE BERKELEY SCHOOL FOR POLICE

In a preliminary communication (Vol. V., No. 5, October, 1922) a brief outline was submitted of a test which is being used every day in the detection of deception. A brief survey of the literature and some of the factors involved in the deception syndrome may be obtained from previous communications of the writer.[1]

The present investigation is concerned with what may be termed 'conscious' deception with its concomitant symptoms, and not with pathological lying. The line of differentiation made by the writer concerns itself with whether the subject is *conscious* of the deception. Such deception may be detected, but not that involved in the paretic who speaks of his millions, etc. A few references of value for the investigator interested in pathological lying, are: Healy, 'Pathological Lying, Swindling and Accusation,' Little Brown and Company; Bernheim, 'Suggestion et ses Applications a la Therapeutique,' 1888; Delbruck, 'Die Pathologisches Lüge, u.s.w. Stuttgart,' 1891; Krapelin, 'Ueber Erringerungsfälschungen,' *Archiv. fur Psychologie und Nervenkrankheiten*, XVII. and XVIII.; Maudsley, 'The Psychology and Pathology of the Soul,' 1870; Sully, 'Die Illusionen, Leipzig, 1884; Forrel, 'Ubergangsformen Zwischen Geistesstörung und Geistiger Gesundheit;' Reinhard, 'Vierteljahrsschrift für gerichtliche Medizin,' 1899; Ripping, 'Die Geistesstörung der Schwangeren u.s.w. Stuttgart,' 1877; Faust, 'Truth and Falsehood.'

The rich literature concerning the association tests with

[1] *Journal of Law and Criminology—American Institute*, Vol. XII., No. 3, Nov., 1921; papers upon 'Deception Tests and Lie Detectors' read before the conventions of chiefs of police and The American Bar Association, held last year—*Police Journal*, Vol. XLVII., Aug., 1922, and the report of the proceedings of the last convention of The American Bar Association.

the reaction time is unessential at this point and it will suffice for the purposes of a deception test to state that investigators disagree as to the efficacy of the words and reaction time as compared with other methods to be described. It is necessary to bear in mind the investigations of Benussi, Burtt and Marston when discussing a practical deception test.

Of these three investigators, the work of Benussi is the first and epoch making.[1] Benussi detected changes during deception by studying the changes in the ratio of inspiration to expiration, 'symptomatic of internal excitement caused by lying, and this was found to be stronger in the case of clever liars than in the easily detected ones.' Although H. E. Burtt confirmed these findings he was inclined to emphasize the changes in quantitative systolic blood pressure. As a result of our investigations the respiratory curve is second to that of the cardiac. That is the respiratory tracings tell more than a so-called significant increase in the systolic blood pressure.

For some years investigators have been attempting to study emotional changes in terms of cardiac fluctuations. Of the various methods employed, that of the plethysmograph, which records the changes in blood volume, is employed in various types of experiments. Thus Mosso[2] and Fere[3] worked with the plethysmograph and pulse tracings in the study of emotions. The plethysmograph is not as satisfactory in a test for deception owing to the variables which may be present.

Pulse tracings have been used as a means of testing deception by some investigators. In those cases the tracings have been secured by some type of sphygmograph. Lombroso has described experiments with the sphygmograph to test the sensibility to pleasure and suggested medico-legal possibilities.[4] He is later alleged to have tested the innocence

[1] 'On the Effects of Lying on changes in Respiration,' *Archiv für die Gesampte Psychologie*, 1914.

[2] LaPaura, 1884, p. 117.

[3] 'Sensation and Movement.'

[4] *Archivio di' psychiatria, neuropatia, antropologia criminale medicina legale*, 1881, n. II., 234, 472.

of an accused by the sphygmograph.[1] More recently this method has been used in conjunction with another by Marston. Lombroso expressed his disbelief in the use of hypnotism as a method of diagnosing guilt.[2]

Attempts have been made by different investigators to record cardiac or other effects of emotions in terms of electrical resistance by various types of galvanometers. There are several objections to the galvanometric method. Marston, in his work, discarded the technique for the purposes of deception. In Jung's 'Studies in Word Associations' in the section treating of the 'psychogalvanic reaction' the statement is made: "Nevertheless, despite numerous experiments, we are still in the region of hypothesis, and do not even know if we really mean the same physiological process under different arrangements of the experiment." Veraguth [3] was the first to take associations with the galvanometer. He noticed that the association curve moved in an ascending line in contradistinction to the 'rest' curve, and that there was a more marked fluctuation with words concerning a complex than with indifferent words. Sticker [4] refers to similar work. Investigators working with the string galvanometer in Guy's Hospital in London have reported results by the association method. Even if successful, the galvanometer is merely recording in terms of electrical resistance what Marston recorded in quantitative terms of blood pressure and the equipment and the technique is such that its use would be prevented as a practical test for deception to be used by police inspectors in cases where extreme emotional disturbances accompany the deception.

X-ray or fluoroscopic studies of the heart action with various methods of measuring changes are not suitable for a practical deception test. The heart's action can be measured and recorded by simpler means, and accurately enough for the detection and measuring of changes such as those occurring in deception as well as other emotional disturbances.

[1] Same journal as above, 1902, XXIII.

[2] Same journal as the above, 1867, VIII., p. 243.

[3] 'Der Psychophysische Galvanische Reflex,' Bericht uber II Kongress fur experimentale psychologie, pp. 219–24.

[4] Jung 'Studies in Word Associations,' pp. 448.

A marked step forward in deception technique is the masterly investigations of Marston.[1] W. H. Marston, a member of the Boston Bar, and now holding a chair in the American University at Washington, D. C., has been a tireless investigator of deception technique. As a result of his preliminary experimentation he stated that estimations of the systolic blood pressure furnished the best criteria for deception. He concluded that an increase of over ten points (mm. of mercury) in the systolic blood pressure was indicative of guilt, and he plotted curves from determinations made by the Tycos sphygmomanometer. He reported from 90–100 per cent. accuracy in his experiments, many of which were made upon students, and also in actual court cases.

The success of Marston's investigations with blood pressure, although recorded quantitatively and intermittently led the writer to the assumption that greater success and still more positive evidence might be obtained by securing a graphic record of the blood pressure curve, *with all of its fluctuations*. Although the pressure may be increased in an examination for some types of guilty individuals, yet in others there may be a depression. Again, in a phlegmatic type of individual the effect of depression may be merely manifested by a single irregular pulsation or slight inhibition in the respiratory curve (Marston preferred the blood pressure measurements to respiratory tracings) which is not enough to cause a significant increase in blood pressure. In addition to the records of blood pressure and those of respiratory changes, quantitative blood pressure determinations are made on one arm according to Marston's technique for a check as well as the reaction time (between the question and the answer) which is measured by a Jacquet chronometer, recording fifth of seconds, and a signal magnet.

Over two years ago the writer and his associates started to use a deception test based upon the correlation between the physiological and emotional activities. In brief, the technique consists of securing a continuous blood pressure curve (secured

[1] 'Psychological Possibilities in the Deception Tests,' *Journal of the American Institute of Law and Criminology*, Vol. XI., No. 4; 'Reaction Time Symptoms of Deception,' JOURNAL OF EXPERIMENTAL PSYCHOLOGY, Feb., 1920.

by an Erlanger sphygmomanometer or more preferably by a modification of the McKenzie or the Jacquet polygraphs) taken synchronously with a respiratory and a timing curve. The respiration is recorded with an ordinary pneumograph such as the Ellis. The procedure is as follows: a normal curve or record is obtained without any stimulus word or question. (By normal is meant the record of the suspect at the commencement of the test, regardless of the physical or nervous type of the individual.) This will of course differ from his condition during actual deception, if present. After a brief period of rest, this is followed by a short prefatory word or 'preamble,' after which a series of questions are given. The questions are of simple nature and must be answered by 'yes' or 'no' (to minimize disturbances incident to the mechanism of speech). With due care no difficulty need be experienced in selecting suitable questions which will probe the deception complexes, if present. After a few questions of an indifferent nature, and which can be checked and a suitable period of rest, the questions bearing upon the alleged crime are given.

At first the stimuli were in the form of association words, the list being selected from the Kent-Rosanoff series with the exception that every third word concerned a possible crime.

As a result of experimentation it was found that for a deception test better and more practical results were obtained when the stimuli were in the form of direct questions and the suspect was requested to affirm or deny all questions. In the hundreds of cases examined, there has not been a single instance in which the desired results could not be obtained by direct questions. The suspect may be either placed in the same room with the apparatus (if so the drums are so rotated that the record cannot be seen by the suspect) or in an adjoining room, or else screened off. As a result of experience it seemed best to have the suspect in the same room. The questions may be given periodically on a revolving drum or else be spoken provided that the examiner be trained to give all questions in the same monotonous inflection of the voice.

The question of coöperation is important and will be

emphasized here because this investigation concerns actual police and court cases tested in the police laboratory. These cases present more difficulties in the detection of deception than in experimental lying conducted with students. In the first place there is the question of legality. The consensus of the opinion of the last convention of the chiefs of police seemed unfavorable to any deception test. Of course, no suspect can be compelled to submit to the test, but of the thousands of individuals examined, only three refused and each was guilty and followed legal advice. In several cases the suspects were tested and then told that their tests were unfavorable and, requested to submit to a second test, they refused. It is significant to note that in each of these cases the suspect lied and was guilty of the alleged crime.

It is relatively easy to elicit the requisite coöperation. The suspect is told that he happens to be under suspicion in regard to an alleged crime and that it is our desire to eliminate him, if possible. The suspect is often glad to have such an opportunity (for in many cases suspicion has been wrongly fastened upon an innocent individual) and if guilty, the suspect does not dare to refuse because he is afraid that such a refusal may appear suspicious. It is important to note that in every case examined the emotion of anger did not vitiate the test in any manner. In fact, if the proper procedure is followed there not only is no anger, but if reported the suspect is open to suspicion. In only two cases have the suspects alleged that anger was present and each subsequently confessed. As a result of the introspection of all of the other individuals, in no case was there sufficient resentment present to be termed anger. In several university students (girls) there was a certain feeling of resentment, but the feeling was generally directed at the entire situation and in no way interfered with the records. Therefore, if the proper procedure is followed, the result is that the reaction of the suspect, if guilty, becomes defensive and his fear increases instead of diminishes with the progression of the test, whereas if innocent, he becomes reassured as the test proceeds, and fear diminishes although under considerable

tension at first. In the case of minors, the consent of the parents is easily obtained.

Aside from the consent of the suspect, the question of evidence of such records assumes legal importance. Here there is a twofold significance, for there is the question of the legality of a deception test in court procedure, and that of the value of a confession which may have accrued through such a test. Marston's adherents have on several occasions attempted to use a deception test in court, but in most instances have met with the opposition of the court. The present attitude of the court suggests that it is too premature to attempt to secure court cognizance Before such an attempt is made there is a necessity for much experimental work with thousands of actual cases of deception, which have been successfully dealt with. It will only be by the correlation and standardization of thousands of cases by experts using uniform technique that the time will be ripe for court presentation. Without data drawn from thousands of cases of deception from all types of temperaments under all conditions a judicial court decision will be impossible. However, for the purposes of practical police investigation the present deception test, or allied ones, are useful for not only may the necessary scientific data concerning the validity of such a test be secured, but the public may be benefited by the solving of cases and the elimination of innocent persons. The present test has in no way interfered with the legal status of the case during the past three years during which it has been in active operation in criminal investigation. In actual police investigation the test is used not to furnish court evidence, except indirectly where confessions result from the test, but as a means of ascertaining whether or not the given suspect is implicated in the alleged crime. The police have been enabled to attack and solve cases in which all other methods had failed. A typical case is that in which forty or fifty or more college girls or men are living in a club and a series of crimes have been committed with no evidence except that someone in the house seemed to be responsible. In such cases the residents are requested (in many investigations they have

demanded to be eliminated) to submit to the test. It is important to mention that after the record is secured, the subject is removed from the room and is turned over to the officer in charge The report of the test is then given to the suspect and in most cases he confesses—if not at the conclusion of the test—then within a few days. The guilty individual then writes out a confession as in any other case and this may be, and has been used as evidence in spite of opposing attorneys. Even though no recognition is ever granted by the courts, a deception test is invaluable wherever there has been any deception.

In conclusion as to the functions of a deception test and its legal aspects, it might be instructive at this point to quote the opinion of an eminent jurist in regard to such tests. The following is an excerpt from the 'Reports of the American Bar Association,' Vol. XLVII., 1922, p. 612: "At the conclusion of his most interesting talk, Hon. Andrew A. Bruce, Professor of Law of the University of Minnesota, spoke on the 'Possibilities and Limitations of Modern Medico-Psychiatric Methods.' He compared the lie detector as a wonderful thing for the probation officer or a man in a penitentiary to experiment with, but was a little doubtful as to its efficiency in a court of law as a positive basis for conviction or acquittal. He very much doubted if a jury could be gotten to pay any attention to a lie detector, and spoke of such a trial as similar to the old time 'trial by ordeal.'"

Before considering any protocols or results, one point in the technique should be emphasized. All mechanical errors should be eliminated by careful calibrations of the instrument, if the instrument has any errors due to changes in position or adjustment. In addition, allowance in the interpretation of the records must be made for different heights of blood pressure. To allow comparisons of records of one individual with another, the same starting point should be utilized. One method would be to start the records of all individuals at an arbitrary pressure, as 110 mm. of mercury. A more accurate method for instruments in which there is a curve showing quantitative fluctuations in pressure (as in the

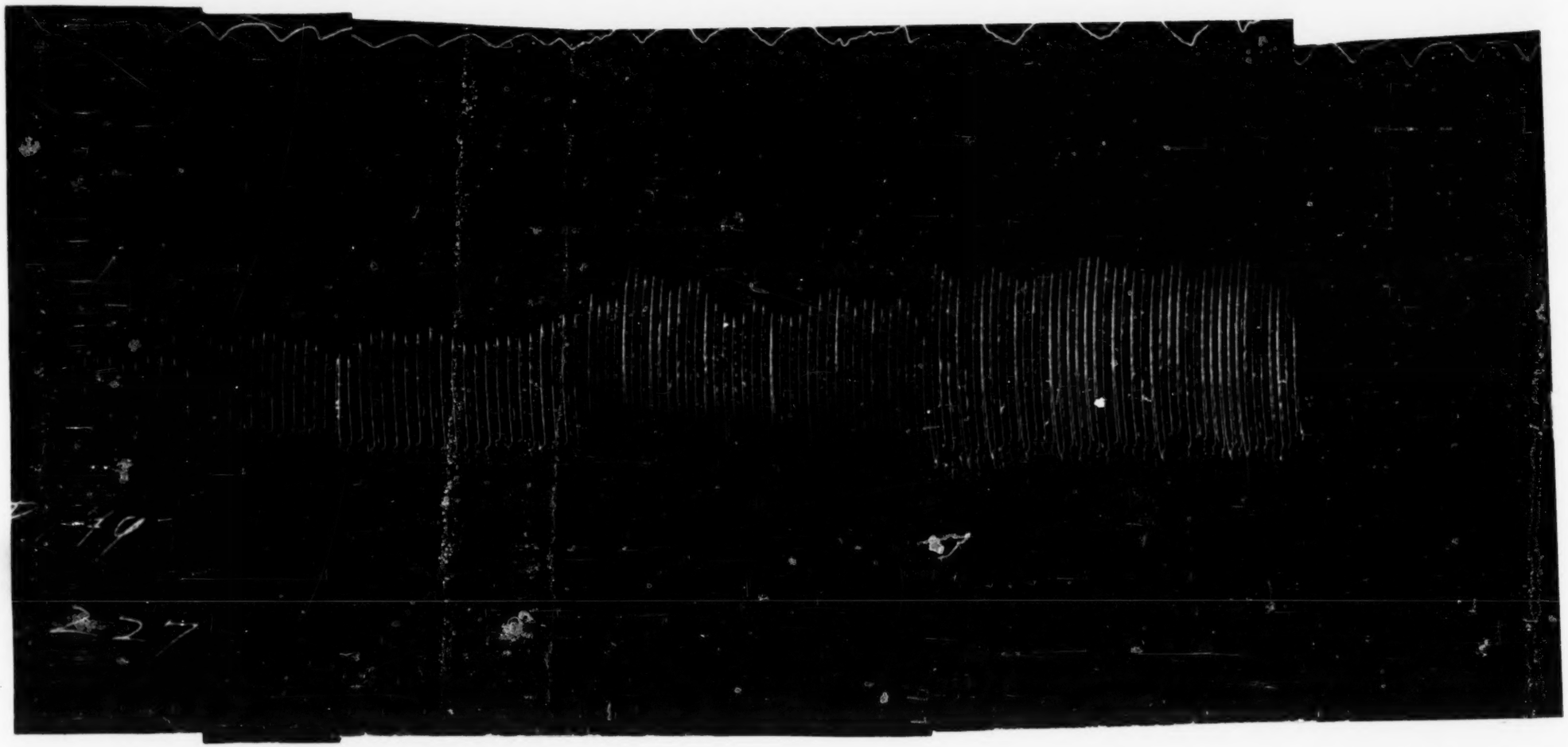
McKenzie polygraph) is to start all records as the systolic pressure for the given individual and in cases where there has been deception followed by subsequent confession the systolic pressures may be different for the same individual, but this difference is experimental as the changes in pressure have been induced by the experiment. It is important for comparative purposes, only, to note the age of the individual, as the pressure varies with the age. In the case of the same individual any level of blood pressure which would permit a record might be used, provided that no further adjustments are made for experimental tension. Deception, if present, will cause changes in the record. Since all changes and comparisons are relative, there are several checks available. Thus the course of the entire record is compared with that of the other. Several individuals may have different systolic levels at the outset. These differences may be due to physiological differences or pathological differences on the one hand, and to differences in tension between an innocent man and one who is guilty. The record of the innocent suspect, usually, will vary but slightly, if at all, from its normal. One of the individual who lies, on the other hand, is not only different from that of an innocent person, but changes occur with deception. In fact, by an attempt to study systolic pressure alone many significant fluctuations would be lost. The record may be commenced with any pressure over the diastolic limit, provided that it is not too high. The systolic readings may be obtained independently on the other arm. The variations due to changes in pressure need not vitiate the record since these are essential with changes in emotional level and no difficulty need be encountered in the interpretation of the records provided that a uniform starting point, such as the systolic level or any other level, arbitrarily selected, as long as the same point be taken as the starting point in all records be adopted.

Owing to the impossibility of using all of the records since there are thousands, a few typical ones will be shown and discussed. Only a few cases will be discussed but each of these will serve to bring out some point of value. The

material to be presented will be divided according to cases and each case will contain whatever points seem significant.

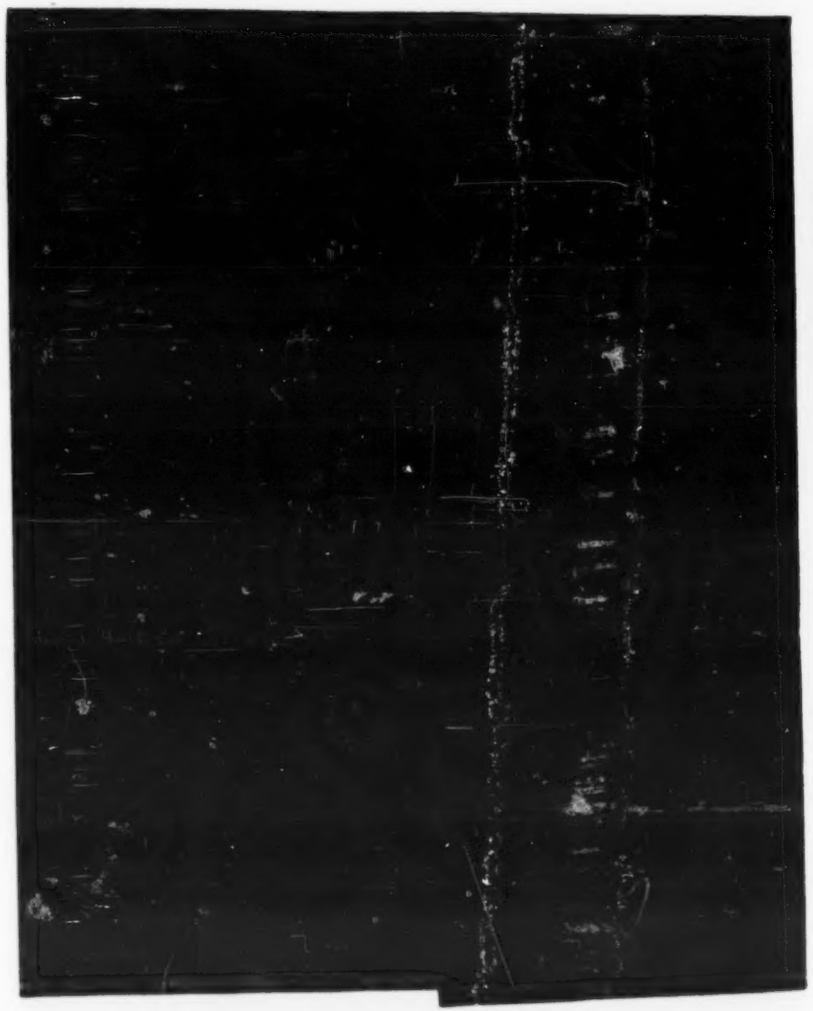
Case I

The typical procedure with the controls used may be seen in the records shown in Fig. 1. Here all of the elements are present except the time reaction line. These records present a very instructive case. In brief, the case is as follows: A prominent resident had been accused of a felony by two individuals belonging to the same family and after a lengthy trial he was convicted. He appealed the case, alleging aside from a few technical points of procedure in law, that he had been 'framed' by the two individuals concerned. Of these two persons, only one was alleged to have been the injured party, the other merely a witness. Considerable feeling was aroused in his behalf and it was believed by friends that the suspect was innocent of the alleged crime. The defendant professed extreme willingness to be tested and after listening to his story, in spite of myself, I was prejudiced in his favor. Some fifteen hours were spent in securing records from all of the individuals concerned and about seventy feet of record secured. The record in Fig. 1 is that of the suspect, the defendant in the case, and that in 1, H.C. that of the individual who made the accusation. A consideration of the records secured led to the opinion that the suspect had lied throughout the test and that the other individual (H.C.) had told the truth in regard to the alleged crime. Record T—1 represents the record of the guilty individual without any question while T—2 represents the record of the individual with the maximum deviation exhibited in response to indifferent questions. Records T—3, 4 and 5 represent the increase in tension, when the stimuli concerned the supposed crime. This record is remarkable for the progressive and regular increase in tension. In this individual the changes were much more significant in the cardiac curve that in the respiratory tracing. The systolic pressure increased from 149 to 184 mm. of mercury in the five minutes in which the suspect was questioned about the crime. This according to Marston's work



T—1 T—2 T—3 T—4 T—5 H. C.

FIG. 1. T—1, at rest and no deception; T—2, indifferent questions; T—3, 4, 5 represents increase in tension due to deception; H. C., no deception.



Deception. At rest—about the murder.

FIG. 2. A murder suspect who was later eliminated.

At rest. Questions about the murder.

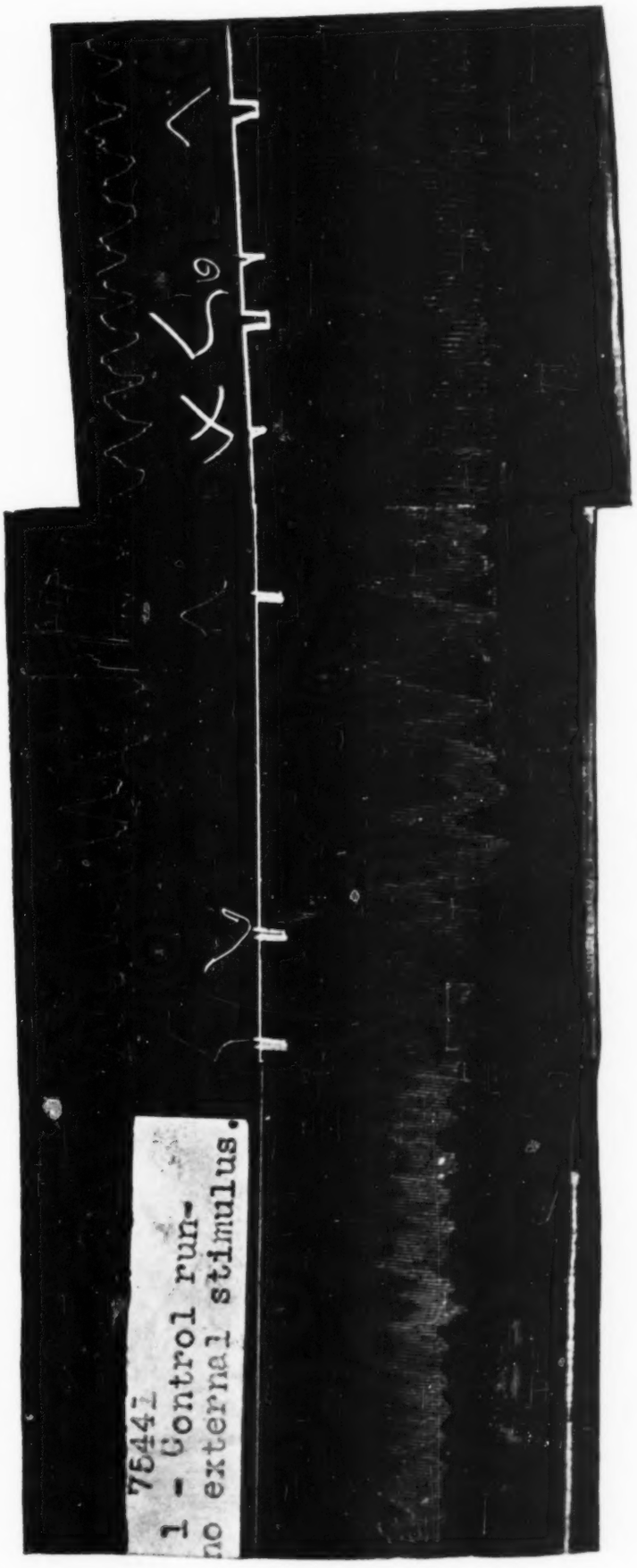
FIG. 3. Record of a murder suspect who was later convicted.

(in which a rise of 10 mm. is considered significant) is indicative of guilt. On the other hand, the record of the individual who made the accusation showed no significant changes whatsoever (Fig. 1, H.C.) although many of the questions were identical, as "Have you lied during this test?"

In the following records, owing to lack of space, much of the control may be omitted but in every case there will be a comparison between a state when there is no deception with that where deception is present. During the last three years, whenever this test is discussed, one query is always raised as an objection to this type of work, and that concerns the innocent suspect who may be of a very nervous temperament. Such a person, when submitted to the ordeal of an investigation might become so emotionally disturbed that the reaction would resemble that of a guilty individual. In note of this objection it will be interesting to examine the record in Fig. 2.

Case II

A murder had been committed in Salt Lake City and three witnesses were alleged to have seen the murderer. A description of this individual was sent throughout the United States and some weeks afterward a tramp was picked up and after questioning it developed that he had recently arrived from the vicinity of the murder. His statements seemed so contradictory and his behavior so strange that his picture was sent to Salt Lake City. The picture was identified as that of the murderer by three individuals and a detective was sent for the suspect. The officers in Richmond, California, where the suspect had been picked up, suggested that he be brought here and tested. Aside from the identification of the photograph, the suspect's own words seemed to implicate him. He not only said that he might have been in Salt Lake City, but that he might have committed the murder. However his record when asked about the crime was as clear as that before, when there was no specific stimuli. As a result of an analysis of his record he was cleared of the crime, assuming that he was capable or conscious of deception. It subsequently developed that he was in jail over a thousand



After confession.

Deception.

FIG. 4. Effect of deception.

miles away on the day of the murder, and the real murderer was later apprehended in Los Angeles and confessed to the deed.

Case III

Shortly after the occurrence of a murder in an unusual manner, a suspect was picked up because he showed he was familiar with the location of the body which had been secreted in a lonely spot. The suspect appeared after a reward had been offered for information concerning the whereabouts of the missing man. Considerable excitement prevailed at this time and the record secured, after the detention of the suspect, under unusual circumstances at midnight. Some several feet of record were secured in the brief time allocated and of these sheets, the sections shown in Fig. 3 are typical. That portion of the record labeled 'at rest' was typical when there were no questions or when the questions revolved about indifferent associations. The effect of repression is seen in the section marked 'questions about the murder.' The result of this test led to the interpretation that the suspect was guilty of deception, and had guilty knowledge of the crime. As to whether he alone or with others committed the crime, no decision could be reached as some of the questions were prohibited by the district attorney. However, the verdict was given out that in the opinion of the examiners the suspect was repressing or that he could tell more about the crime than he had, and so, had guilty knowledge. The same guilty type of reaction was obtained when he was questioned concerning an alleged alibi as to where he was on the night of the murder, as when questioned in regard to whether he committed the crime. The suspect was promptly convicted and sentenced to life imprisonment upon the strength of evidence gathered in the police investigation. During the trial his alibi was completely shattered.

Cases II. and III. are valuable as they represent extreme types in which a correct decision was made possible before the real facts were known. Since the alleged crime was the same in both cases, the maximum amount of tension would be expected and yet in spite of a positive identification a

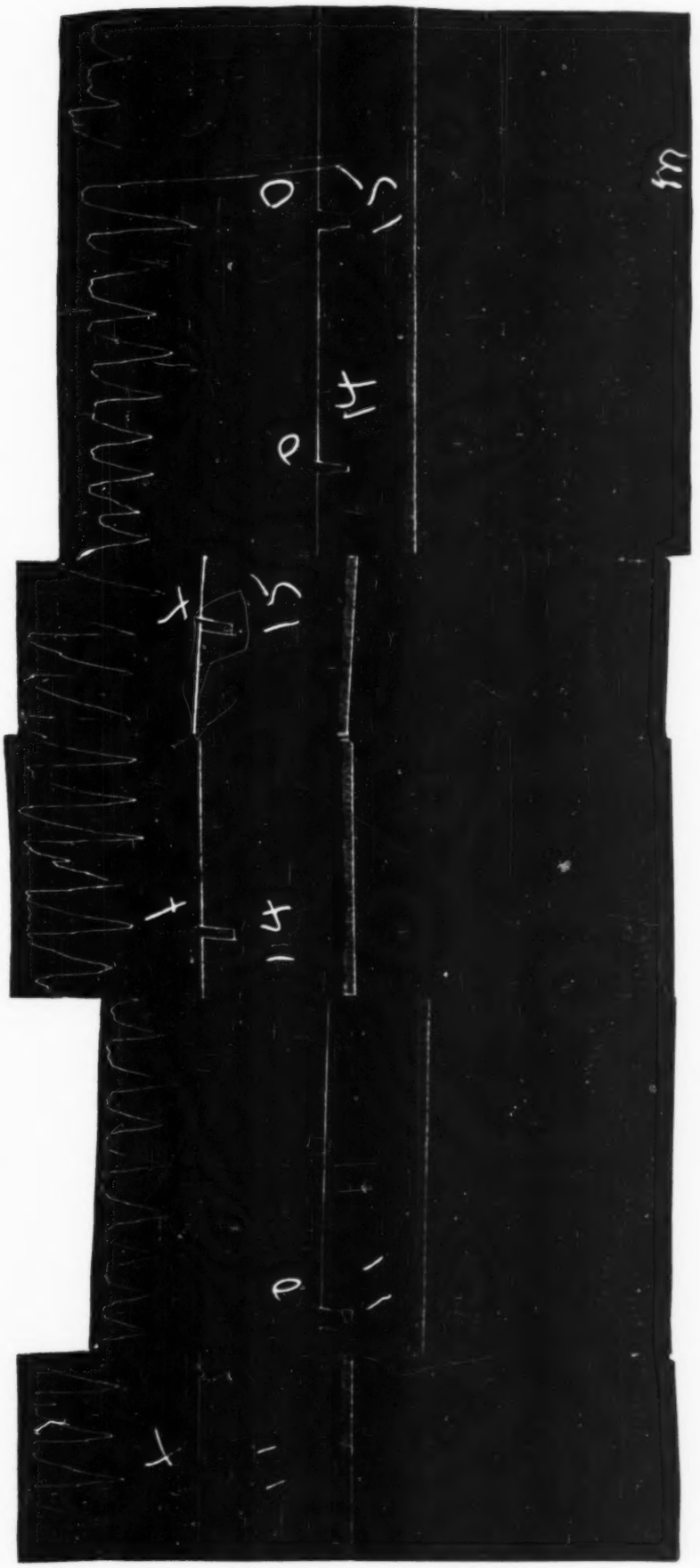
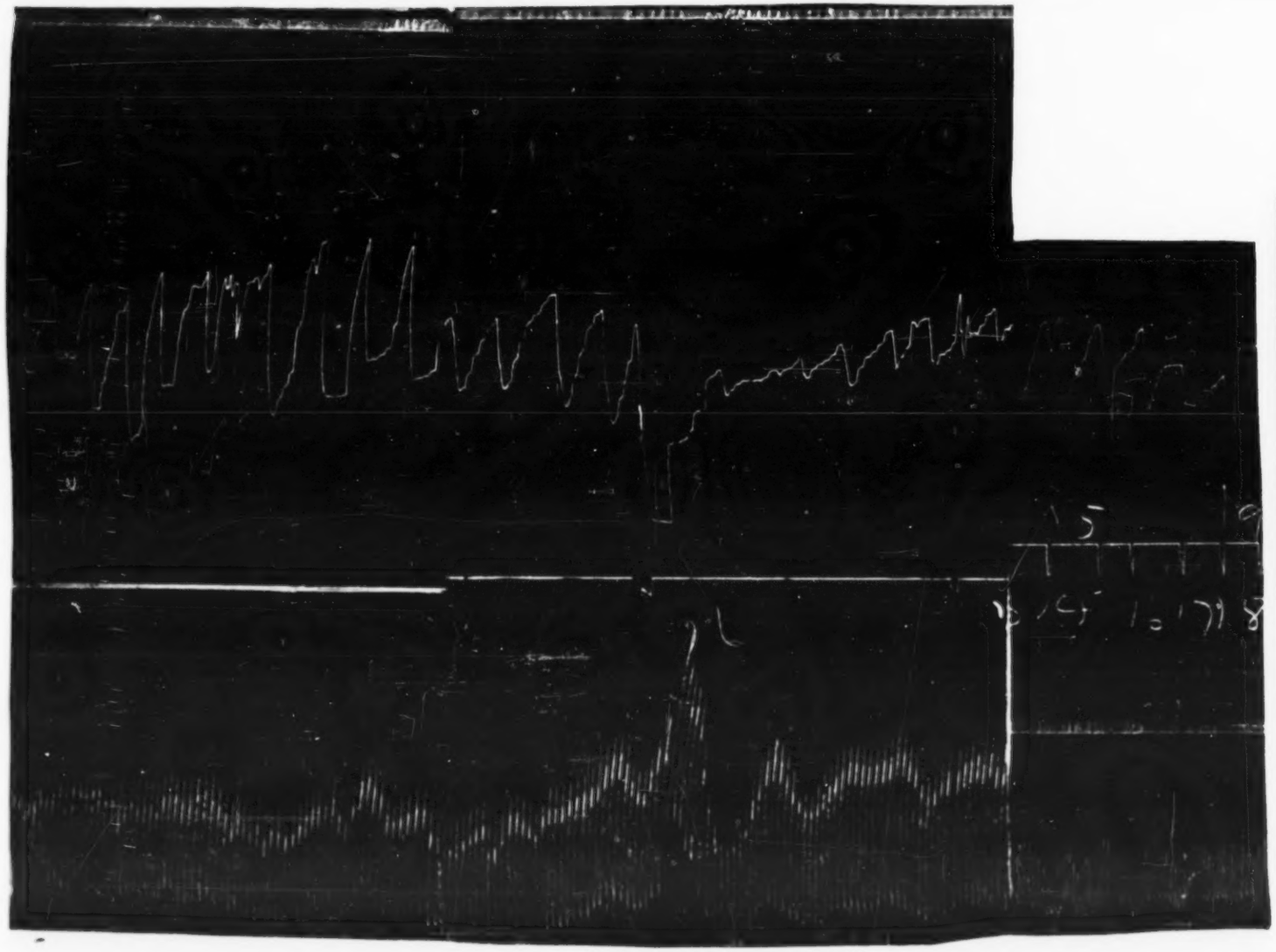


FIG. 5. 77334 Male.

friendless stranger was eliminated, while in another case the suspect was implicated in a murder although the examiner had less to work on as far as evidence was concerned than in the first case. In both of these cases the suspects had been quizzed repeatedly and their statements did not clear up the case. In other words, both of these suspects knew that they were under suspicion and yet it was relatively easy to control the reactions. In neither case did the systolic blood pressure show any significant rise (over 10 mm.). In the foregoing cases the problem of the criminalist or expert was to detect whether a given suspect was innocent or guilty of the alleged crime. In these cases the individuals were already under suspicion and the problem was one of elimination. A frequent problem encountered in police investigation is to select a thief from a group of thirty or more individuals when the only evidence available is that someone or more individuals are responsible.

Case IV

The records shown in Fig. 11 were taken from a group of 38 girls. According to information received from a clerk someone in a group of 38 college girls who were living together in the same house, was a shoplifter. The entire group was tested within sixteen hours at the laboratory, and of course all were given the same questions. The record of the girl in Fig. 11 is that of the girl who was selected because of her record, and after two tests, several days apart, in which the same type of record was secured, she confessed. It seems that she had stolen so many books and fancy trinkets that the girls deemed her rich. She admitted having sold over five hundred dollars worth of books, as well as articles from the stores and clothing taken from her roommate, in various places. Each set of records is divided into three divisions. The first of these is termed the 'normal' although this may not represent the real condition for there may be an increased tension due to the nature of the test, to the nervousness of an innocent suspect or to the fear of the guilty. It has been found from experience that in the case of the innocent, the tension usually remains at about the same level, decreases,



At rest. Deception at 16. After confession.

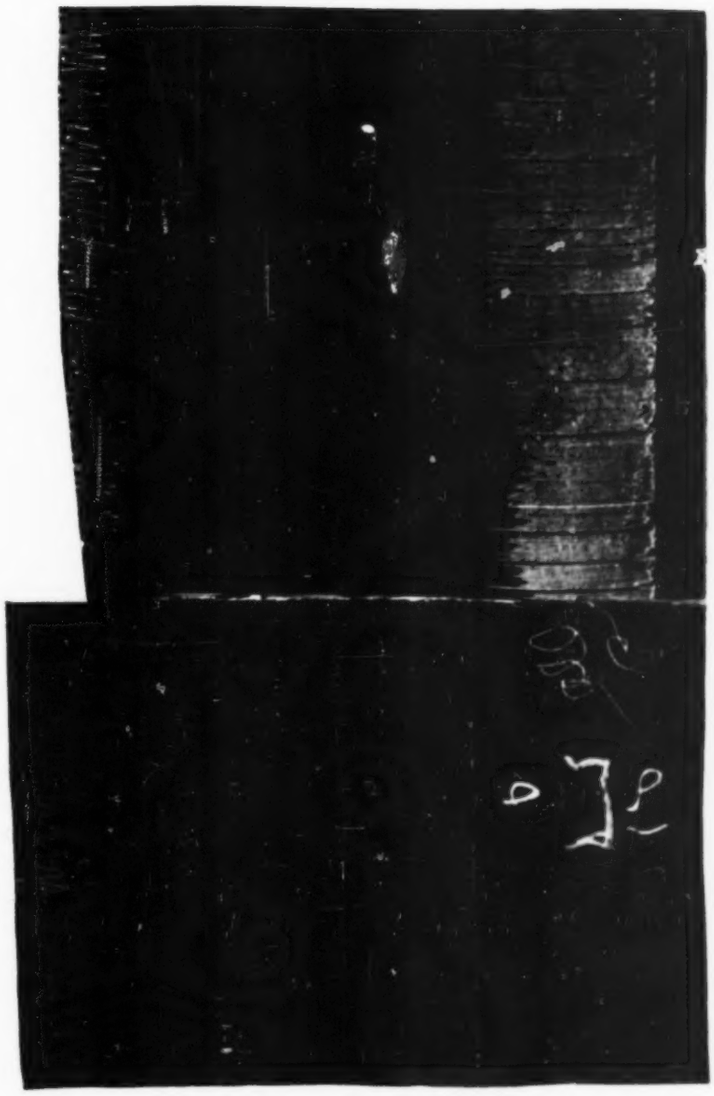
FIG. 6.

FIG. 7. Clear record of a suspect.

or else fluctuates slightly, whereas in the case of the guilty suspect in whom the tension is increased by deception, the record changes and often very markedly. The record which is typical of the innocent girls, Fig. 11*a*, shows no significant changes throughout the test. On the other hand, the record of the girl, Fig. 11*b*, who was guilty of the shoplifting is different from the beginning. In her so-termed 'at rest' portion of the record she is seen to be under considerable tension as compared with the 'at rest' portion of the others. (In this record the cardiac curve is more significant than the respiratory and this is usually the case.) In spite of this however, this girl is assumed to be innocent and merely of a more nervous temperament than the others unless this change becomes increased. (In such cases the increase is usually due to deception.) As a matter of fact, the tension becomes markedly increased with the result depicted in the record. The question here arises as to how absolutely a line can be drawn between what are termed indifferent questions and those relevant to the alleged crime. Too distinct a line cannot be drawn of a necessity for inmost cases the suspect does not know when the crucial questions are coming and so there may be emotional disturbances in some individuals. This may be often marked in the guilty, but absent in the innocent ones and this may be termed an 'anticipatory' effect. It is interesting to note that the shoplifter afterwards admitted that she had stayed up all of the night preceding the test playing cards so that she could have a good alibi by saying that her record if poor, was due to fatigue, etc. The systolic pressure of this girl fluctuated between 136 and 130 mm.

Cases IV. and similar ones are instructive for the relative rôle of anger and fear of the innocent suspect in relation to the interpretation of the records may be studied. Here of all the girls who were examined in an unusual environment and where all were under suspicion, the record of only the shoplifter was selected. Thus the fear of the innocent when questioned in regard to the alleged crime need not invalidate the test or interfere with the interpretation of the records. As to the presence of anger the result of the introspection of

FIG. 10. Effect of confession at 4.



Rest. Deception.

FIG. 8. Block due to deception. FIG. 9. Effect of deception upon a poor heart.

all of the girls involved show that anger was vouchsafed only in the case of the girl who had lied.

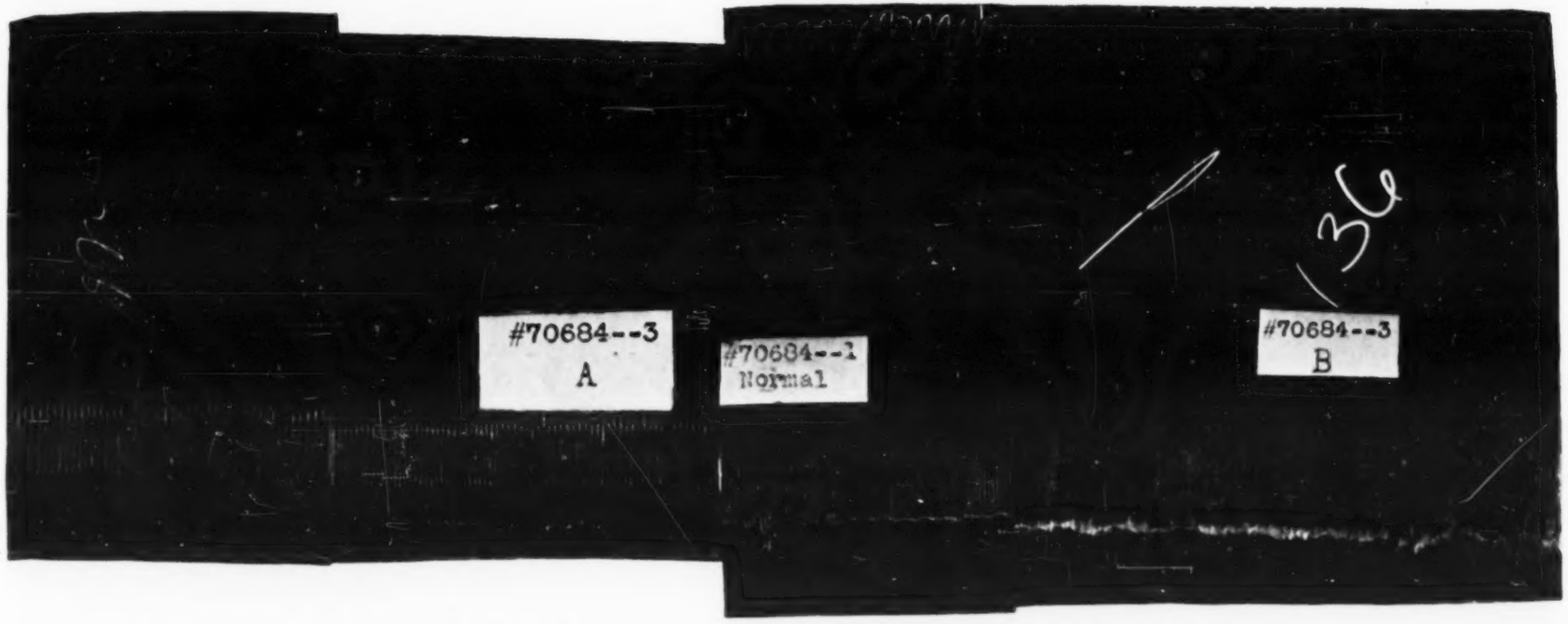
The effects of deception differ markedly from those of a confession. Thus the records 4, 5, 6 and 12, depict the different effects in the same individual.

Case V

A woman reported that a twenty dollar bill had been taken from the house and from the survey of the premises it was thought that the theft had been committed by a burglar as the window had apparently been jimmied. For elimination purposes a friend of the family was brought in as he was the last person in the house. In fact this individual was engaged to the girl living in the house and he was brought in more to discuss the case than as a suspect. He volunteered to be tested and the following ten questions were the first ones asked:

1. Do you object to this test?	No.	No.	No.
2. Do you smoke?	Yes.	Yes.	Yes.
3. Do you like your position?	Yes.	Yes.	Yes.
4. Do you like the movies?	Yes.	Yes.	Yes.
5. Do you like to dance?	Yes.	Yes.	Yes.
6. Did you take a $20 bill from the house?	No.	No.	Yes.
7. Did you just lie?	No.	No.	No.
8. Do you gamble?	No.	No.	No.
9. Have you ever been arrested?	No.	No.	Yes.
10. Did you take the $20 bill?	No.	No.	Yes.

Aside from the sullen demeanor of the suspect nothing definite had been secured from him until the test. During the first portion of the test his record seemed indicative of some tension (Fig. 4). No significant change occurred in response to the fifth question, but marked changes were noted following the sixth question, the changes being significant in both the respiratory and cardiac curves. As a result of the first test he was held twenty-four hours for investigation in which time his record was looked up as the test indicated that he had lied in reference to his contact with the police. The officer in charge of the case spent the day following the



At rest. 11—A. No Deception. At rest. 11—B. Deception.

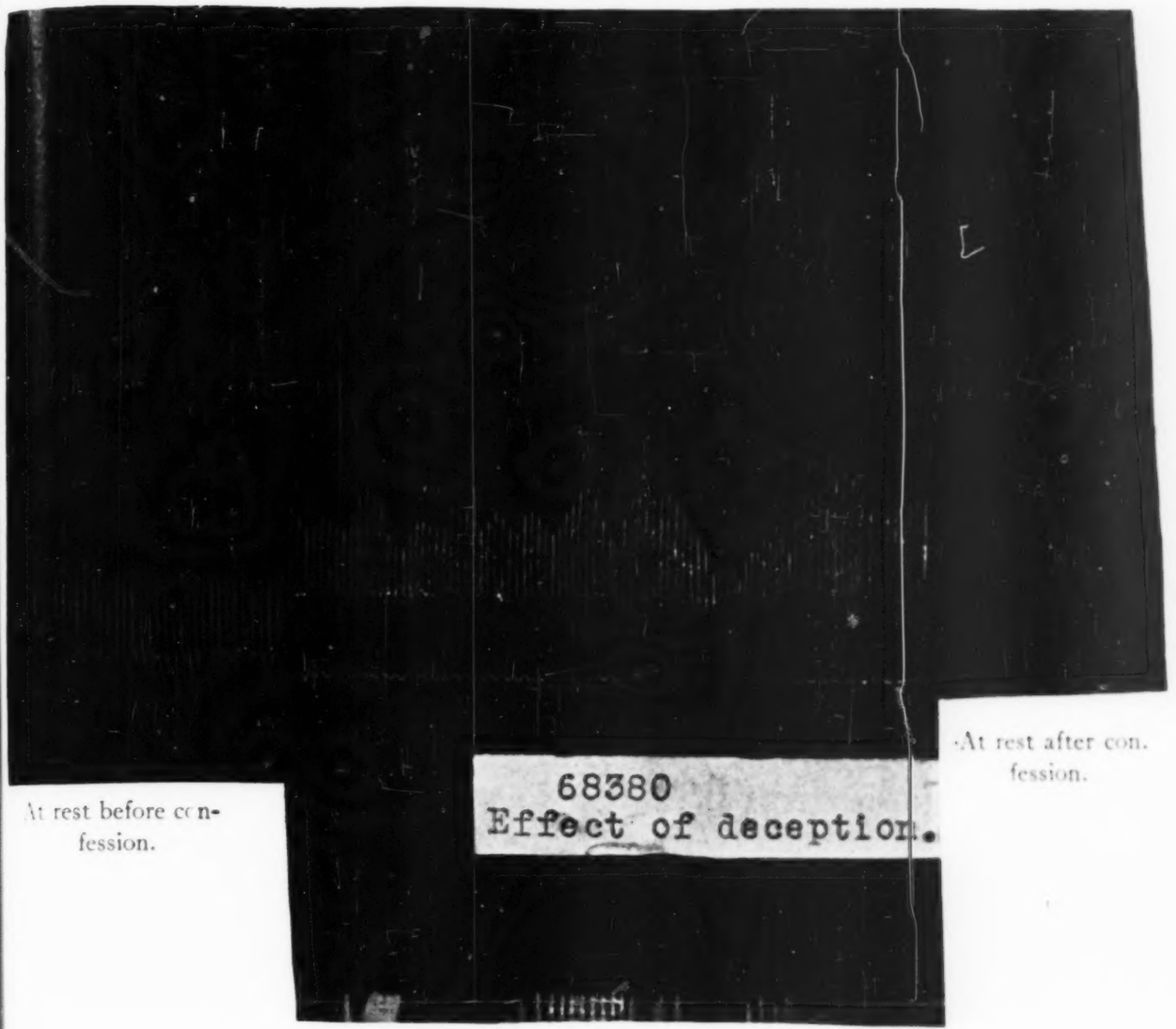
Typical of 37 innocent girls.

FIG. 11. Record of a shoplifter who was picked out of 38 girls as compared with a typical innocent record, no deception present. Reaction time line omitted by photographer.

test in checking upon alleged alibis and was so convinced of the suspect's innocence that he wanted to release him. I requested that another record with the same questions be obtained. This was done and the same type of reaction secured, with the result that the suspect confessed. This record was then followed by another test with the same questions, but there were no disturbances in the tracings. The suspect afterwards stated that while he was in the penitentiary such deception tests had been discussed and most of the crooks thought that detection was impossible and that the test was mostly bluff with strange apparatus. However, after he was shown the records, he stated 'the record has the goods on me.' In all of the records before the repression had been removed, changes were discernible in the heart and respiratory curves, but not in the reaction time or by any determinative increase in the systolic blood pressure. Often in this type of case the systolic blood pressure does not increase more than five or six points during deception, but if the suspect confesses, the pressure is usually lower as the repression has been removed. The systolic pressure varied from 124 to 130 mm. of mercury during deception, but after confession the beginning and terminal pressures were 104 and 107 mm. However, before this increased tension due to deception is detected, the deception itself must be determined, and this is obviously impossible in the above type of cases, since the suspect's pressure was at a guilty level to commence with—that is, as compared with his same level after confession.

Case VI

This is a typical case in which a sex invert is brought in for investigation and vehemently protests his innocence. The record of the suspect is shown in Fig. 6, in which he is seen to be emotionally disturbed before any questions are given. It might be mentioned that this suspect was suffering from a badly dislocated jaw and at first attributed his nervousness to that. A typical reaction of this individual during deception is seen in response to the sixteenth question. This record was followed by a confession and in this record the real



Effect of deception following one question.

FIG. 12. Record of a clever burglar who lied and later confessed.

normal of the individual may be seen as compared with the first portion of the tracing. In this case, marked tension may be seen in the respiratory tracing in the tremulousness of the waves in addition to the inhibitory effect caused by lying. In this case the reaction time curve did not differentiate between true and false answers. The initial systolic blood pressure was 166 mm. of mercury for the first test and 156 mm. at the conclusion of the test, in which deception was present. However, after confession, the beginning and terminal pressures were 120 mm. and 110 mm. respectively. As

in the above case, the individual's level was much higher during deception than after confession, but this cannot be ascertained during the test without the removal of the repression.

The following case deals with a typical recidivist and tends to show the relative efficacy of a deception test upon men who have spent a large portion of their lives in eluding and tricking the police.

Case VII

The record in Fig. 12 is that of a very clever crook. For months cordons of special details had been patrolling the city to apprehend a burglar known as the 'daylight burglar.' He was finally picked up in the southern part of the state through his description and method of working, which had been circularized throughout the state. Upon looking up his record it was found that he had earned the sobriquet of the 'Eel' because of his facility of slipping out of tight places, especially after he had been apprehended. He consented to submit to the test, although he was then awaiting an attorney, but stipulated that the record should not be submitted as evidence. In addition to some study of law and a long career as a burglar he had served as a spy during the war and had been twice deported.

This suspect knew that he was going to be questioned upon a series of burglaries which he was alleged to have committed and which netted the burglar some thirty thousand dollars. Fig. 12 illustrates fluctuations in tension when at rest and in response to indifferent questions, one of which is seen in Fig. 12. The extreme blocking effect of deception in this individual is represented by the record in Fig. 12. Here when the suspect lied concerning a question which implicated him in the burglaries he became so disturbed that he requested that the test be discontinued shortly after the record shown in Fig. 12. He later confessed and his normal record may be seen in Fig. 12.

Case VIII

One Sunday evening an elderly man was found begging in a church in the wealthiest section of the city. Upon his

arrival at the station he was at once recognized as an ex-convict with a long criminal record, and he was addressed by his correct name. The man not only denied his identity but also denied having been in the city before. It was decided to attempt to ascertain what crimes, if any, he was responsible for in this city. With that end in view, some forty questions were prepared, some of which concerned his record while the remaining ones were to furnish an insight into his criminal activities in this immediate vicinity. Some of these latter questions dealt with forgery, others with highway robbery, some with burglary. After some hesitation, the suspect submitted to the test and the record was similar to that of 12. Shortly after the instructions, in the form of a preamble had been given, he refused to answer any questions which involved his various names. Even without a record such a refusal would be suggestive. However, although no answer was obtained, the effect of the painful complex is manifested. Since I knew from experience that this disturbance could be intensified by actual deception, I stopped the test and persuaded him to answer the remaining questions by "yes" or "no," provided the questions were to be confined to this city alone. After proceeding with the test I found evidence of deception only in reference to the crime of burglary. A search was then made in the files for burglaries which had been committed since he left prison. Questions were formulated in reference to these crimes and evidences of deception appeared only in reference to one burglary. This man refused to discuss the test or the questions and accordingly instructions were then left for the inspector to investigate this burglary. The investigator encountered no difficulty in eliciting a confession after the suspect had been confronted with conclusive evidence of his guilt.

Case IX

This is a very instructive case, for the suspect, in addition to a long record of burglaries and holdups, was a drug addict and was saturated with morphine. Although he was apprehended in a burglary, he refused to confess or discuss the

case at all. He readily submitted to the test and an excerpt of his record is seen in Fig. 10. An interesting effect is shown in response to the fourth question. This question, if answered affirmatively would implicate him in a burglary and send him to the penitentiary. Between question and answer there was a long latent period, indicated in the record by a long reaction time as well as a slight increase in tension shown in the cardiac curve. It is important to note, however, that with the admission the curve became perfectly regular and could not be differentiated from the true answer to the fifth question. The slight emotional upset present, concerned the deliberation as to whether to confess or not. In such cases there is usually a marked, lengthened reaction-time, which is longer than that shown in question 10 in which there is real deception. Usually the effect of confession is not differentiated from that of the other true responses. However, if there is any effect it is similar to that seen in the fourth question and precedes the admission. In some cases where the effect lasted until the following question, it was seldom carried beyond the next question. Nor were there any effects with subsequent confessions.

In the above account, mention was made of the suspect's giving up a diamond after the test. This episode is somewhat analogous to the case of a clever forger who denied any complicity in the alleged crimes. Within five minutes after the test had commenced, the suspect asked for a rest and he then took out twenty dollars from the bottom of his shoe. He gave this up rather than be caught with it, according to his confession.

In every case yet encountered the recidivist and so-termed 'hard-boiled' crook affords as much, if not more, evidence of deception than first offenders. A common procedure in the case of clever crooks such as confidence swindlers and card sharps, is for them to submit to the test and then refuse to answer questions which would implicate them in the alleged crime, or any questions which would bring unpleasant facts to light. Of course, in addition to the disturbances in the record, such procedure at once pointed out their painful

complexes. Of all of the recidivists the confidence swindlers and card sharps afford the best criteria for the efficacy of the test, for if anyone, aside from the insane, would be expected to mask his emotions, they would be the likely ones. As a matter of fact, two men arrested for a crooked poker game furnished as significant records as anyone.

Case X

This case is somewhat related to that of the 'Eel' in Fig. 12 as the man involved was brought to the station as the burglar wanted. The individual concerned was picked up as he answered the description and his modus operandi was identical to that of the man wanted. In spite of the fact that the suspect's own testimony implicated him in several of the burglaries in that he admitted being in the neighborhood of the crimes and going from house to house soliciting garden work in the same manner as the 'Eel,' the inspector could not obtain a confession from him. He was submitted to the test and was eliminated in ten minutes after having been interviewed for two hours without avail. A typical section of the record that eliminated him is seen in Fig. 7. Of course, a check was obtained some days later with the confession of the burglar. Thus this elimination of a stranger who could not clear himself and expected to be tried for the crimes committed by another, again illustrates that practically, innocent persons suspected of a crime may be cleared.

The record of Fig. 8 is of interest because here the effect of deception causes a drop in pressure with the obliteration of the pulsations in the cardiac curve. The curve of Fig. 9 is that of a person who was suffering from irregular cardiac action and yet this did not interfere with the test. Here deception caused an increased frequency in addition to the irregularity.

Case XI

Case XI. attracted considerable attention owing to the chain of events which led to the obtaining of the record which indicated deception. Over a year before, a wealthy rancher was disturbed by having his safe burglarized and the

use of a check book obtained at the time of the burglary. A check for a considerable sum of money was forged. At that time suspicion fell upon the son, who was sent from home and sometime after commenced to deteriorate mentally and suffer from spells of amnesia. Some time later a man was apprehended for forging a check from a blank obtained in a burglary. This forger asked the probation officer to ask —— for a letter of recommendation, and —— remembered that this man had worked for him at the time that his son was supposed to have forged the check. The father then solicited the aid of this department. The suspect submitted to the test and his record seemed indicative of deception. As a check upon the record, exemplars of the handwriting of the suspect, together with the check, were sent to the best handwriting expert available and he found forty-three points of identity. Therefore, upon the strength of the handwriting, the modus operandi and the deception record, the father reinstated the son.

Case XII

This case is one that might be termed 'experimental' deception. Once in a while an individual comes in to us with the query as to whether the deception test will be applicable in situations where there is no real fear or emotion involved. In such cases it should be emphasized that a failure of any type of deception test in cases of lying where the deception may be just for the purpose of determining whether a test works or not, does not invalidate the same test in practical criminal cases in which the suspect may experience the deepest possible emotional tension. In the case of the individual who desires to be detected, the procedure is relatively simple. Instead of elaborating a set of questions which may excite the individual, the subject is told to write out ten simple questions upon any subject whatsoever, and to lie only on one or two questions. He is instructed to lie on only one or two questions, not only so that there may be a number of questions which may be used as checks, but to save time and prevent the subject from lying on all. In this way through the focusing of attention upon only one or two

points, the reaction becomes much more marked and detection seems to be easier. In at least ninety per cent. of such cases attempted, detection has been made possible by studying the changes in the pneumo-cardio-psychogram. The record in Fig. 13 is that of a girl who was told to lie only once, and

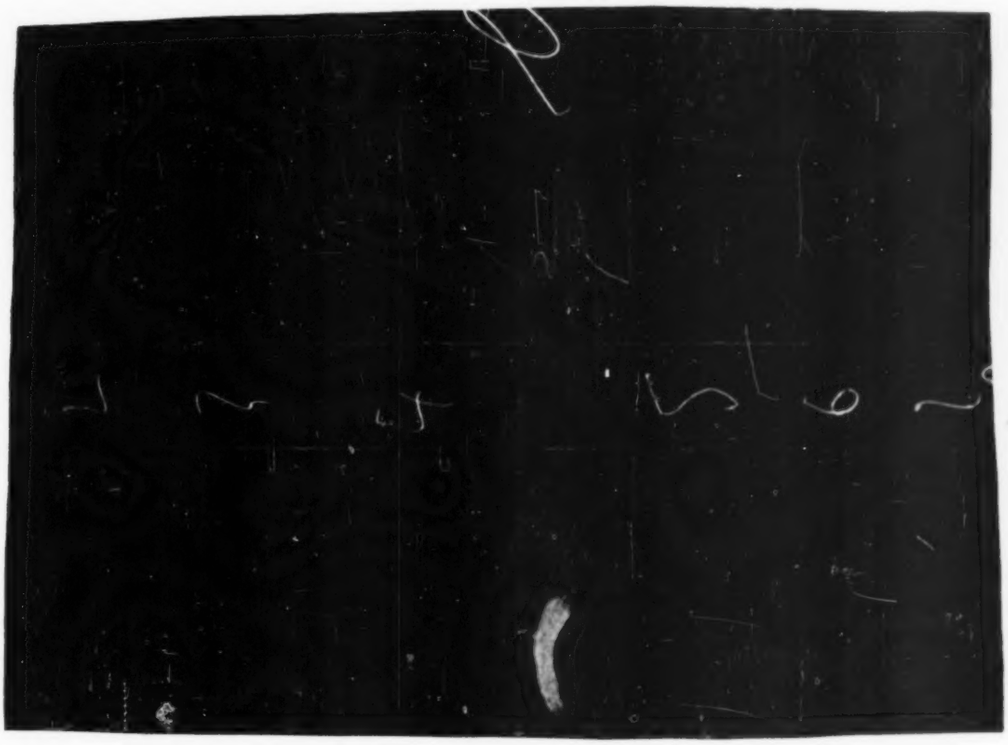


FIG. 13. Record of experimental deception. Not this much disturbance as a rule in experimental work. The girl lied at the fourth question.

the fourth question was the one chosen by the examiner. This agreed with the number written upon a slip of paper by the girl before the test. As before mentioned, such experiments should not be too critical criteria for comparison purposes with deception concerning painful complexes as in criminal investigations. In this both of the cardiac and respiratory curves were markedly affected by the repression, although there was no significant change in the reaction time, and the systolic blood pressure did not vary over nine points. Before leaving the subject of experimental deception, it might be well to reiterate that checks on deception in such investigations as reported here cannot be obtained in the laboratory where students are used for subjects, and the selection of the

subject matter is arbitrary. Confirmation or denial of this type of work must be done in actual cases where all of the variables are present and basic emotions underlie the experiments. Secondly, the investigators must be trained and experienced in contending with all types of temperaments. It is from the type of such investigators as Marston, experienced in experimental work with students, and actual criminal investigation, that decisive protocols and data relative to a deception test are to be obtained. Much helpful and corroborative material may be obtained from experimental work in the laboratory with the students, but it is only from the heterogeneous assemblage of material which confronts the court and the criminologist that the most decisive data is to be secured.

The foregoing are a few typical records and illustrate various types or reactions during deception. The type of reaction under tension will vary with the temperament of the subject. A higher degree of tension will be created in a nervous dynamic individual, than in one in whom there is a thyroid deficiency. The following changes have been observed as the effect of deception: (These may occur in both the cardiac and the respiratory curves or in one alone, more frequently in the cardiac action.)

1. Increase in blood pressure—a rise.
2. Decrease in blood pressure.
3. Increase in height.
4. Increase in frequency.
5. Summative effects.
6. Incomplete inhibition.
7. Complete inhibitory effect.
8. Irregular fluctuations, especially noticeable at the base of each cardiac pulsation.
9. Combination of any of the above effects in the same individual.
10. These changes may occur with but little latent period, or then may be accumulative in effect and more generally distributed.

Record 1 furnishes a classical example of a gradually increased tension up to a maximum in which there is an increased height and frequency associated with a marked rise in blood pressure. There is a remarkable regularity. In this record the changes are of little importance in the respiratory tracing. In record of Fig. 3, the cardiac curve again is that most instructive for diagnostic purposes, as here there is an increased height and a partial summative effect in which one pulsation is superimposed upon another. The various types are illustrated in the few curves shown.

In way of recapitulation the following results seem valuable and suggestive:

1. The cardio-pneumo-psychograms afford a convenient and simple method of recording some of the physiological effects of emotional variations.

2. Of the various records which may be secured of the cardiac action, sphygmographic, apex, carotid, venous pulse, cardiogram (secured by string galvanometer), plethysmograph, that of the blood pressure curve with the pulsations seems the most convenient for the detection and analysis of the deception syndrome.

3. The cardio-pneumo-psychograms afford an excellent means for the probing and detection of painful complexes.

4. In all of the cases yet examined, the analysis of the cardiac and respiratory curves appear to afford more decisive evidence and are of more aid in the detection of deception than that of the reaction time.

5. Better results may be obtained when the stimuli in a deception test are in the form of direct, simple questions.

6. The graphic method of study of the cardiac and respiratory action affords more satisfactory results than the study of the increase in systolic blood pressure alone. Of the two the cardiac curve affords the most frequent and decisive data.

7. In all cases of deception yet examined, the records differ from those, not only of the same but different individuals, in whom no deception is present.

8. It is possible in cases of conscious deception, to show the difference between the record of an individual before and after confession, when the same questions are asked.

9. The effects of anger or fear of the innocent suspect in an alleged crime need not vitiate the interpretations of the record, provided that the proper precautions are used. In fact, in practical procedure these effects can be so minimized as to allow interpretation of the records with a reasonable degree of accuracy.

10. In practical application of the present test it has been possible to select records of the guilty from those of the innocent suspects before a confession. This has been done in about ninety per cent. of the cases. How much greater than ninety per cent. the determination is, cannot be learned, owing to the disappearance of the suspect, inability to obtain a confession, or innumerable other causes.

11. Pathological or physiological factors do not interfere with the interpretation of the records, provided that the suspect is conscious of deception, if present, as the condition of the subject can be obtained in the first portion of the test. Thus the time of day, relation to meals, sleep, etc., in no way interfere with the test since the changes in the record are relative and the condition, pathological or physiological, is ascertained at the beginning of the experiment and any changes due to deception will cause variations in the record. In some cases the writer has obtained typical effects although the suspect had fainted and in one case had experienced an epileptic attack just prior to being questioned. Again, innocent suspects who were trembling and even crying at first, were easily eliminated during the test.

12. The experience of the suspect need not interfere with the interpretation of the record. The records of recidivists in crime are as easy to interpret as those of first offenders.

13. In cases of so-termed 'experimental deception' (where students are instructed to lie for experimental purposes and the element fear can play but an unimportant rôle), definite changes may be found, but not as easily as in criminal cases of deception. Such cases should not be used to check the relative efficiency or practicability of a test in actual court cases of deception or wherever a deep fundamental element is involved.

14. As a result of actual operation in criminal investigation, the present technique seems to afford a practical and relatively simple means of detecting deception. In this work any man endowed with ordinary intelligence and who has had experience in handling court and criminal cases, can learn to conduct the test with a fair degree of accuracy. It is significant to note that three officers, Dean, Waterbury and Wilson, and Inspector Greening, who have had no previous training except in police investigation, have operated the test successfully in at least ninety per cent. of the cases handled by them.

15. A wrong interpretation does not invalidate this test as the record is permanent and does not depend upon any opinion of the examiner, but when definitely checked, can be used as a criterion for the next case of a similar nature.

16. Of course, in records where the emotional changes are so apparent and the different phases of the same individual can be seen in the same record, measurements are unnecessary. The data including inspiratory-expiratory ratios, frequency changes, etc., will be later compiled from the hundreds of cases tested for comparative purposes. The most convincing factors are those which can be easily observed, such as differences in the records in the same individual before, during and after deception.

Although investigators have attacked the problem of a suitable deception test for years in both the physical and psychological laboratories, the masterly work of Marston, Benussi and Burtt have aroused new enthusiasm in this, as yet, pioneer field. It will only be by the tireless efforts of such investigators that the necessary coöperation will be stimulated with the ultimate result that through the combined work of all the deception syndrome may be analyzable quantity. Whether the final and best apparatus is the Tycos or Erlanger sphygmomanometer, the pneumograph, galvanometer, reaction-time, or combinations of all, is immaterial as long as decisive insight may be gained towards the solution of the problem.

In reference to court procedure, these records are perma-

nent, are easily preserved and could form the basis for court use if the necessary standards or data are first accumulated. However, to qualify as experts to pass upon these records with scientific accuracy the expert should be a person with a sound psycho-pathological knowledge and a student of abnormal behavior. The changes are so often so striking that they can be easily recognized by the members of the jury. With the proper coöperation and securing of hundred of thousands of check cases (which could be obtained in a reasonable length of time, as thousands of records have been obtained just from this one laboratory in a short period of time) the time might then be ripe for the introduction of a deception test into court procedure.

THE INFLUENCE OF CONSTITUTIONAL FACTORS ON BEHAVIOR

BY SANTE NACCARATI, Sc.D., PH.D., AND
HENRY E. GARRETT, PH.D.

From the Department of Psychology, Columbia University

In any study of human behavior two factors, or groups of factors, are now generally considered to be responsible for the appearance of individual differences—namely, heredity and environment. A growing organism is, in general, subject to the action of two systems of forces: the internal—those inherited through the germplasm—and the external—those residing outside of it in the environment. Of the two determinants, the second, being the most obvious, is usually assigned first place; and it is only of late (largely through the efforts of eugenists and geneticists) that due weight is being given to the hereditary factors as influences in human conduct. For education, however, the external factors are still of preëminent importance.

This same state of affairs, *i.e.*, the greater importance of the external factors as against the internal, may be observed also in medicine; the causes of disease are usually sought in morbid factors which enter the organism from without—germs, poisons, traumata. It has only been since the development of endocrinology as a branch of medicine that a better understanding of another important group of morbid causes, viz., the endogenous, has been reached. These causes, according to endocrinologists, are inherent in our organic makeup, in the more or less solid structure of our body, in the variable functional capacity of the individual organs whether congenital or acquired during the period of development of the organism.

The study of the constitution has shown that endogenous factors cannot be traced to heredity alone. During the pre-

natal life, one or more endocrine glands of the unborn may undergo structural or functional changes by accidental causes independent of heredity. Infections, toxic agents, emotions are to be considered among these causes. There is no doubt about the influence of infections and toxic agents playing accidentally on the offspring before birth through the maternal organism. As for the emotions, the popular belief is very old that psychic and moral traumata in the mother during pregnancy may affect the unborn organism. Here endocrinology enables us to understand how the hormonic secretion of the fœtus may be affected by a psychic shock of the mother, and gives a scientific explanation to a belief which has generally been looked upon with scepticism and ridicule. We may say that the endocrino-sympathetic equilibrium of the fœtus was altered through the influence which the mental condition exercises on the hormonic secretion and vice versa. The emotions as well as the intoxications and infections are external factors in the mother, but the changes that they start in the fœtus from that moment on have to be regarded as accidental internal factors. Once the endocrine glands of the newborn begin to malfunction, its hormones will determine morphologic, neuro- and biochemical changes which will appear later on in the mature organism in a manner that will puzzle the most experienced psychologist if he wants to attribute the abnormal behavior to heredity and environment alone.

It is clear that the same infectious and toxic causes which act on the fœtus through the maternal organism may also act directly on the child during its postnatal development, thus determining physical and mental changes which will vary according to the quantitative and qualitative disorders which they produced in the endocrine organs. And since mental changes when due to endogenous causes connected with the endocrine glands are usually accompanied by morphologic changes or characteristics also (because of the influence which the hormones exercise on the morphogenesis as well as on the nervous system and the metabolism), therefore a systematic study of the morphologic type of a given individual should yield valuable information concerning his mental status also.

Pende (1) has made an attempt to study body development from the point of view of endocrinology. Of the hyperthyroid constitution, which corresponds to the microsplanchnic type of Viola, he says: "From the morphologic point of view, in clean-cut cases, the subjects show . . . precocious and pronounced morphologic differentiation, longitudinal diameters of the body in excess over the horizontal diameters . . . habitual thinness hardly overcome by hypernutrition . . . diminished carbohydrate tolerance; accelerated basal metabolism, great irritability of the vegetative nervous system, especially of the sympathetic subdivision, marked psychic irritability, hypermotivity, cerebral restlessness . . . precocious and often pronounced intelligence development." In opposition to this type which he calls microsplanchnic, Viola has recognized another type, the macrosplanchnic or megalosplanchnic, which he considers an infantile type because it shows poor morphologic differentiation. In the macrosplanchnics the development of the trunk predominates over that of the extremities when trunk and extremities are considered in relation to their reciprocal dependence. This type also possesses a large and very active visceral system, a large cutaneous surface in relation to body volume, anabolic processes in excess over catabolic. Between these two types is the normosplanchnic type, which shows harmonious and proportionate development of trunk and extremities. There are, of course, many intermediate cases, the morphologic types in general following the normal curve.

Ravà (2) in a recent study has found that neurasthenics and psychasthenics are mostly found among the microsplanchnics and that manic-depressives are mostly macrosplanchnic types. Ravà thinks that emotional and instinctive individuals are opposite types and considers the neurasthenics as emotional, the manic-depressives as instinctive. Therefore, for this author, the microsplanchnics are mostly emotional types while the macrosplanchnics are instinctive types.

These findings in abnormal psychology and psychiatry have been sketched at some length in order to show how the study of the *habitus* may help in the analysis of personality.

Following the Italian morphological school led by De Giovanni (3) and Viola (4), we have, for some time, believed that normal individuals of the two opposite types—the microsplanchnic and the macrosplanchnic—will give mental and physical performances that will correlate with their morphological development. When due allowance is given to race, sex, age, and diseases suffered by the individuals whose morphologic characteristics we want to study, we can, with a fair degree of probability, determine which are the hormones that have acted on the soma before birth. The thyroid hormones furnish a good example. We know that they influence growth, differentiation, and intelligence. If they are in defect during the development of the organism, we will find the evidence of such defective activity in the retarded differentiation—poor growth, and defective mentality. The best example of this is, of course, the cretin, who is poorly differentiated physically and mentally. We may say with Viola that here the morphologic evolution did not take place; the original evolutive spurt proceeded along the ponderal line alone. This is only one example, and only one gland; to go into details concerning the effects of all the endocrines would take us into a far more lengthy discussion than was contemplated in this brief report.

Experimental researches in America on the relation of morphology and performance were begun in 1919 by one of the writers (5) and were continued later with Lewy-Guinzburg (6). A correlation of .23 was found between the ratio of height/weight and intelligence as measured by the Thorndike Intelligence Examination for a group of 221 college men. With a group of 75 men, the correlation between the 'morphologic index' (see p. 12) and intelligence was found to be .36. These correlations, while low, are sufficient to warrant the assumption of an actual interrelation between body development and intelligence. No study of the relation of the bodily development to other capacities, sensory or motor, was made in either of the above researches, and the present experiment was planned, therefore, for the purpose of determining whether there is any relation between the body growth and the speed and flexibility of the individual's mental and motor processes.

The experiment is divided into two parts. In the first part there were 57 subjects ranging in age from 17 to 25 years, all college men of Sophomore or Junior grade, enrolled in the elementary psychology courses in Columbia College.[1] All of these students had taken the Army Alpha examination as a part of their class work, and their marks on this examination were taken as a valid measure of intelligence.

As we were restricted, in this experiment, to the use of tests capable of being given as group tests, many good tests were ruled out. After some preliminary trial the following tests were selected:

Pitch Discrimination.
Rapid Coördination.
Rapid Recognition.
Maze Tracing.
Auditory Memory for Digits.
Cancellation: A test and Number Group Checking test.
Controlled Association:
    Subordinates,
    Part-Whole,
    Opposites,
    Mixed Relations.

The pitch discrimination test was the familiar Seashore test given by means of the phonograph record. The rapid recognition and rapid coördination tests were taken from the Taylor Intelligence Tests. In the first test the subject is given a page of jumbled numbers, from 1 to 50, which he is to join by lines, going from each number to the one which follows it in consecutive order. The score is the last number reached in the time allowed. In the second test, the subject is required to draw four vertical lines and one line through them (in the form of a gate) as rapidly as possible. The score is the number of groups made in the given time interval. The auditory memory test for digits and the maze tracing tests are well enough known to make description unnecessary.

[1] The writers are indebted to Messrs. Jones and Lecky, Instructors in Columbia College, for permission to use their classes.

The cancellation tests were the familiar A test and the number group checking test of the Woodworth-Wells series. The controlled association tests were also taken from the Woodworth-Wells series of controlled association tests.

In the cancellation and association tests, since these tests were all given as group tests, the time required was taken as the best measure of capacity. The score in Cancellation was obtained by combining the A test and the Number Group (the relative weights being 1 : 2). Greater weight was given the second test because of its greater difficulty. In controlled association, the four tests were averaged, all with same weight. For this group of tests, as well as for maze tracing, the few errors that occurred were considered equal (7) and were corrected by arbitrarily adding 1 sec. in controlled association, and 2 secs. in maze tracing to the individual's uncorrected time.

After the tests had been given, the height and weight of each man was obtained and his height/weight ratio calculated. From the group of 57 men, we then selected the fifteen having the highest, and the fifteen having the lowest ratios. The morphologic indices of this group of 30 men, who form the main experimental group, were then calculated and the performances of the two groups on the tests compared. The size of the two groups made comparison either by the P.E. of the difference or by overlapping impossible or useless; therefore, the averages, S.D.'s, and ranges are merely stated. The results of this comparison are meant to be suggestive rather than conclusive.

In the second part of the experiment are given the results of the performances of 50 men and 50 women on the two cancellation tests, and the four association tests. This group of 100 formed an auxiliary group for correlation of these tests with the ht./wt. ratio, and for comparison with the main group of 57. The group was composed of men and women from graduate and extension courses; the range of ages was high, probably 17 to 50; the report of height and weight often admittedly crude; hence the results from this group are not as reliable as those from the more homogeneous and better measured group of part one.

TABLE I

$N = 15$

	Group I	Group II
MORPHOLOGIC INDEX		
Aver.	594.2	447.0
S.D.	45.4	44.2
Range	682–525	504–337
AUDITORY MEMORY FOR DIGITS		
Aver.	8.5	7.8
S.D.	1.5	1.7
Range	6–11	6–12
RAPID RECOGNITION—120 SECS.		
Aver.	31.2	31.3
S.D.	5.3	5.1
Range	22–40	23–41
CANCELLATION—A TEST AND NUMBER GROUP		
Aver.	108.0	112.2
S.D.	16.1	16.2
Range	74–135	77–142
CONTROLLED ASSOCIATION (Sub.-PW-Opps-Mixed Rel. combined)		
Aver.	196.5	237.5
S.D.	26.8	35.8
Range	164–275	174–285
MAZE TRACING		
Aver.	110.2	135.6
S.D.	13.2	26.0
Range	90–135	115–255
RAPID COÖRDINATION—40 SECS.		
Aver.	34.0	30.5
S.D.	4.7	3.9
Range	25–40	24–37
PITCH DISCRIMINATION		
Aver.	74.0	81.5
S.D.	11.1	8.3
Range	56–88	60–95
ARMY ALPHA		
Aver.	171.0	167.5
S.D.	18.9	20.8
Range	138–203	126–195

In Table I. are given the performances of the two groups of fifteen each, selected as above outlined. Group I. is made up of those men having the highest morphologic indices; and Group II. of those men having the lowest morphologic indices. It is worth noting the fact that only two men in the group of 30 were shifted from one group to another as a result of the use of the morphologic index instead of the ht./wt. ratio.

The figures in Table I. show first of all the clear separation of the two groups as regards morphologic index. In auditory memory for digits, rapid recognition, and rapid coördination, the differences are negligible. The relatively small range would indicate that in the two latter tests the time was too short or the tests too easy; probably both factors operated to give these tests little or no discriminative value. The slight superiority of Group I. over Group II. on the Alpha is due, no doubt, to the smallness of the sample, and to the more important fact that Group II. is made up of normosplanchnics rather than of macrosplanchnics. In speed of controlled association, in maze tracing, and to a lesser degree in cancellation, Group I. is better than Group II.; in pitch discrimination the second group is ahead.

Table I. indicates further that only in cancellation, controlled association, maze tracing, and pitch discrimination is there enough difference between the two groups to make the use of correlation worthwhile for the group of 57. The results of the correlation [1] between the ht./wt. ratio and the tests for the group of 57 men are given in Table II. The correlation of ht./wt. and Alpha is also given.

Table II

$N = 57$

r (ht./wt. ratio and Alpha)	$.31 \pm .08$
r (ht./wt. ratio and cancellation, A test and No. Group)	$.21 \pm .08$
r (ht./wt. ratio and controlled assoc.—4 tests)	$.44 \pm .07$
r (ht./wt. ratio and maze tracing)	$.37 \pm .08$
r (ht./wt. ratio and pitch discrimination)	$-.014 \pm .09$

[1] All correlations in this report were computed by the Product-Moment Method.

Table II. serves to substantiate, through correlation of the tests with the ht./wt. ratio, the results indicated in Table I. Except for the negative correlation between ht./wt. and pitch discrimination, the correlations for Alpha, cancellation, controlled association, and maze tracing are all positive, and in the case of the Alpha, controlled association, and maze tracing substantial. The large P.E.'s are due to the size of the sample.

In Table III. are given the correlations between the ht./wt. ratio and the combined cancellation tests, and the combined association tests for the auxiliary group of 100. In order to make the group as large as possible, the records for the 57 men in the first experiment were combined with the 100 men and women who were given only the cancellation and the association tests. Seven men from the first group who were also in the second were eliminated making the number of cases in the group exactly 150.

TABLE III

$N = 150$

r (ht./wt. ratio and cancellation, A test and No. Group)	$.22 \pm .05$
r (ht./wt. ratio and cont. assoc.—4 tests combined)	$.24 \pm .05$

As in Table II., the correlations between the ht./wt. ratio and both the cancellation and the controlled association tests are positive and, while not as high as in the more homogeneous group of 57, are more reliable. These correlations serve to add weight to those obtained in the first group, and make it fairly certain that the interrelation between body development and speed of motor and mental performance is not a chance one. One other set of correlations was found: the correlation between ht./wt. and cancellation and controlled association for the men and the women taken as separate groups. These results are incorporated in Table IV.

TABLE IV

$N = 50$

50 Men:	
r (ht./wt. ratio and cancellation)	$.19 \pm .09$
r (ht./wt. ratio and controlled association)	$.17 \pm .09$
50 Women:	
r (ht./wt. ratio and cancellation)	$.13 \pm .09$
r (ht./wt. ratio and controlled association)	$.11 \pm .09$

In all cases the correlations are low, and the P.E.'s are so large that none of the correlations are reliable. This result is to be expected in view of the relatively heterogeneous group from which the records were obtained; chance errors too, and they were unavoidably frequent, would tend to 'attenuate' the coefficients.

In spite of the many limitations in this experiment—which we have tried to indicate—we believe that our data warrant several conclusions:

1. The positive relation previously found between physical development and intelligence is substantiated by our results.
2. In speed and flexibility of mental and motor performance as measured by cancellation, controlled association, and maze tracing, those individuals with high morphologic indices surpass those with low indices.
3. There is no correlation between pitch discrimination and morphologic index as far as our results are concerned.
4. The relation between morphologic type and speed of movement and association seems to be higher for men than for women, though the difference is slight.

In order to make clear the exact meaning of the 'morphologic index' as this term is used in this paper, the following table of the measurements taken in computing the index, with an explanation of its meaning, is given. For a detailed description of the morphologic types the reader is referred to the original work of Viola, or to ref. (5). (All of the following measurements are made in cms.)

1. Height.
2. Length of sternum: from the jugular incisure to the point of insertion of the ensiform appendix.
3. Xipho-epigastric line: from the point of insertion of the xiphoid appendix to the epigastric point. This point is at the crossing of the middle vertical line of the trunk with the horizontal line passing through the lower margin of the tenth rib.
4. Pubo-epigastric line: from the epigastric point to the upper margin of the pubis.

5. Transverse thoracic diameter: breadth diameter taken at the level of the 4th rib.
6. Transverse epigastric diameter: taken at the midpoint of the xipho-epigastric line.
7. Antero-posterior thoracic diameter: depth diameter taken at the level of the 4th rib.
8. Antero-posterior epigastric diameter: depth diameter taken at the same level as the transverse diameter.
9. Transverse pelvic diameter: taken between the iliac crestæ at the point of maximum breadth.
10. Length of upper extremities: from shoulder to stiloid processes.
11. Length of lower extremities: from the upper margin of the pubic bone to the external malleus of the foot.
12. Weight: in kgs.

After these measurements have been made, the 'morphologic index' may be calculated by dividing the length of two limbs (sum of the lower and upper extremities) by the volume of the trunk. In this paper the first three figures have been taken as representing the index.

References

1. Pende, N. Le debolezze di costituzione. Roma, 1922.
2. Ravà, G. Costituzione neurastenica e costituzione distimica. *Giornale di Psichiatria clinica e Tecnica manicomiale*, 49, 3–4, 1921. Istinto e Emozione, ibidem, 1–2, 1922.
3. De Giovanni, A. Morfologia del Corpo Umano, Milano, 1891.
4. Viola, G. Studi di Morfologia Clinica (in De Giovanni, A.). *Lavori dell'Istituto di Clinica Medica di Padova*, Vol. 2, Milano, 1905. Nuovi Studi di Morfologia Clinica (in De Giovanni, A.). *Lavori dell'Istituto di Clinica Medica di Padova*, Vol. 4, Milano, 1909.
5. Naccarati, S. The Morphologic Aspect of Intelligence. New York, 1921.
6. Naccarati, S., and Lewy-Guinzburg, R. L. Hormones and Intelligence. *The Journal of Applied Psychology*, September, 1922.
7. Garrett, H. E. A Study of the Relation of Accuracy to Speed. *Archives of Psychology*, 56, 1922.

THE EFFECTS OF UNDERLEARNING UPON SHORT- AND LONG-TIME RETENTIONS

BY EDWARD CHACE TOLMAN

University of California

The results to be reported below were obtained by the use of a new form of memory-apparatus; and the reason for presenting them is primarily to demonstrate the uses of such an apparatus.

In the 'Methods of Complete Learning' (Erlernungsmethode) and of 'Saving' (Ersparnismethode) as these were originated by Ebbinghaus [1] and elaborated by Müller and Schumann [2] the subject is required to read over the given material at a given tempo until he can finally recite it without looking on. In so doing, he is encouraged to begin to recite any syllables he already knows as soon as possible. The particular advantage and new feature of the apparatus to be described is that it is able to record the points of incidence and the progress of such recitings. But in order to achieve this, certain changes in technique were introduced. Instead of the tempo being governed by the presentation apparatus itself, the earlier Ebbinghaus method of reading in time to an auditory beat (in our experiments a metronome) was returned to. And, instead of requiring the learning of all the syllables we required merely the learning of the second ones of each pair. The introduction of this latter change, however, was primarily because it seemed to make the learning more stable and uniform. And our apparatus, although described to suit this new method, could easily be remodelled to fit the method of learning *all* the syllables.

Our general procedure was as follows: The lists were typewritten in pairs—the two syllables of each pair, side by side; but the pairs one under another. The apparatus con-

[1] Ebbinghaus, H., 'Über des Gedächtnis,' Leipzig, 1885.

[2] Müller, G. E., und Schumann, F., *Zeitschrift für Psychologie*, 6, 1893–4, 81–190.

sisted of a rectangular frame about 7 x 10 inches (see Fig.) made of cardboard strips (*B*) tacked to a piece of board serving as a base (*A*). The strip of paper (*C*) bearing the typewritten syllables was slipped into this frame in such a way that the second syllables of the pairs—typewritten to the right of the first syllables—could be covered by the end of sliding cardboard strips (*D*). These sliding strips were movable through a distance of about an inch. When moved from left to right they uncovered the second syllables. When moved in the reverse direction they covered them up again. These movements were produced by the subject himself by putting the point of his pencil into small holes (*E*) in the middle of the cardboard strips. As he then moved a strip from right to left and back again, thus uncovering and covering up again the required second syllable, his pencil traced a mark (*F*) upon a strip of ordinary adding machine paper (*G*) inserted underneath. In this way a record was obtained of every time he had to look at a second syllable.

The detailed procedure may be stated as follows: The list to be learned was slipped into place with all the strips of cardboard pushed over so only the first syllables of the six pairs showed. The subject, in time to the metronome, read aloud the first syllable of the first pair. He then on the second beat of the metronome uncovered and covered up again the second syllable of the pair which was typewritten to the right of the first syllable. On the next beat he read the first syllable of the second pair which was directly below the first syllable of the first pair and then on the fourth beat uncovered and covered up again the second syllable of the second pair—and so on—down through the six pairs. (In all the experiments reported 6-pair lists were used.) In so doing, a record was made by his pencil of the fact that he had to uncover (*i.e.*, look at) each of the 6 second syllables before he could say them. After the first repetition, he drew through the adding machine paper to a fresh section and was ready immediately for a second repetition. As soon as possible he attempted to say (*i.e.*, recite) the second syllables without uncovering them. And whenever he was successful, this

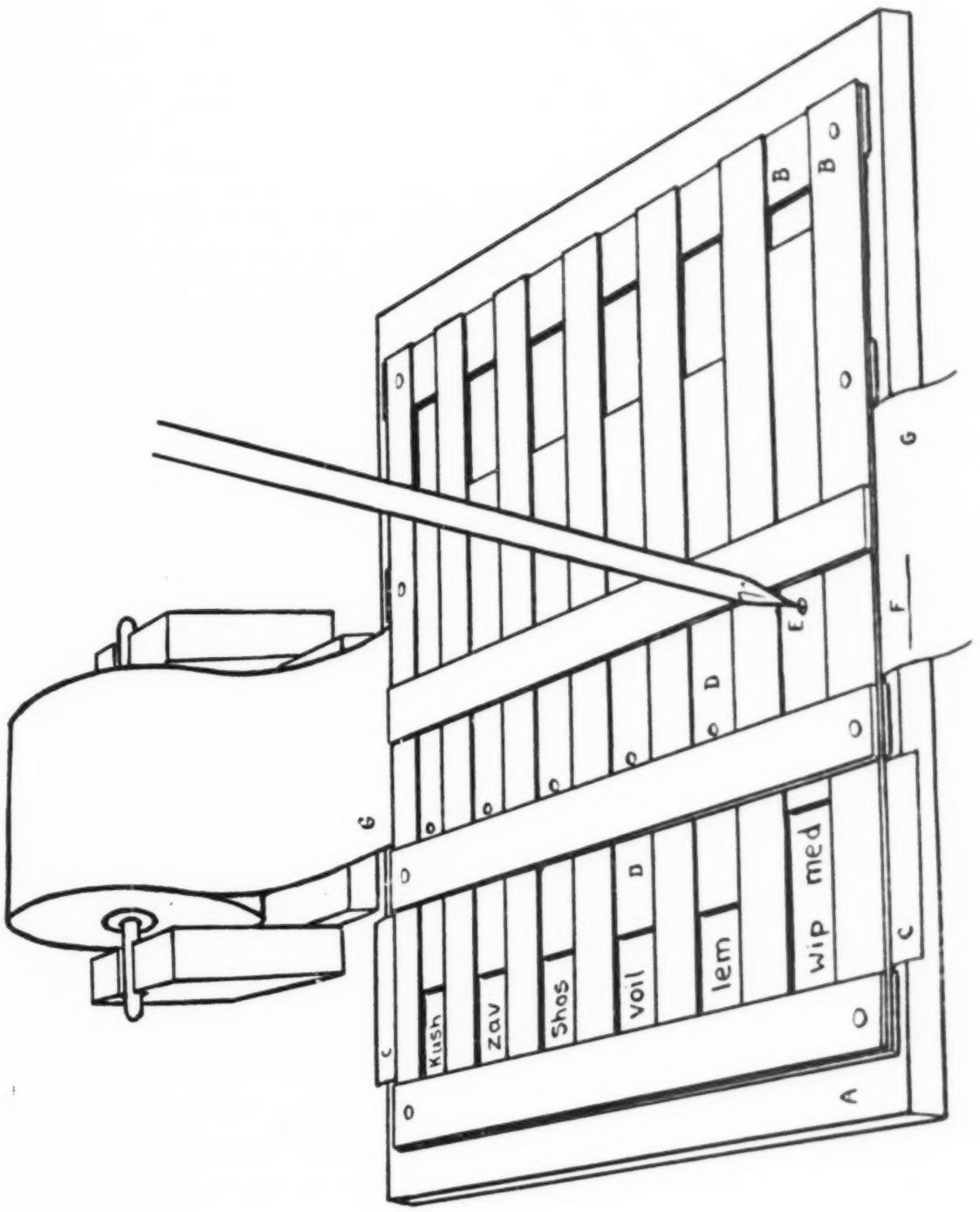
showed on the adding machine paper by the absence of a pencil mark. When he had succeeded in saying all 6 second syllables without looking at them, the list was learned. The adding machine paper thus gave a record not only of the total number of repetitions but also of which particular syllables had to be looked at and which were recited in each repetition. After a list was learned, the record could be rolled up, dated, numbered, etc., and filed without the subject's counting the repetitions or otherwise noting the outcome, until the final completion of the whole experiment.

In the actual experiment now to be reported two sets of results were obtained. In the one set, lists were learned and then relearned after an *interval of 5 minutes*. In the other set, they were learned and relearned after an interval of *one week*. It also happened (because of another purpose which need not concern us here) that in both cases results were obtained for two sub-conditions which may be called respectively efficient and inefficient. *In the 5 minute tests* these two sub-conditions were in all cases merely two different times of day: morning and afternoon or morning and evening. In the one-week tests the contrasted conditions were also, for most of the subjects, two times a day, but in the case of two subjects they consisted of a dose of caffeine on the one hand and a control dose of sugar of milk on the other. In the case of the 5-minute intervals the relearning conditions (times of day) were, of course, the same as the corresponding learning conditions (time of day). *In the case of the week intervals* the relearning condition was the same for both types of learning condition. That is, morning-learned lists and afternoon-learned lists were in the case of some subjects both relearned in the morning, in the case of other subjects both relearned in the afternoon (*i.e.*, an interval of exactly one week in some cases and of one week plus half a day in others). The caffeine- and non-caffeine-learned lists were for both subjects relearned under non-caffeine.

Other conditions were as follows:

Five-minute Intervals:

There were seven subjects and each of them after some days of preliminary practice learned and relearned four lists a day: two at a morning hour and two at an


B
B
G
F
E
D
D
G
C
C
A
kush
zav
shos
voil
lem
wip med

afternoon hour making 70 efficient lists and 70 inefficient lists or 140 in all. The subjects were senior students in an advanced laboratory course and they performed the experiments at home. The metronome rates while constant for any one subject varied between subjects. The lists used in this experiment were of a special type in that three-place numbers were attached to the second syllables. These numbers were typed just to the left of the second syllables and close enough to them to be covered and uncovered by the cardboard strips. The subjects were thus required to learn and recite not merely the second syllables but also their attached numbers. (The reason for this added complication was in order to make the material sufficiently difficult so as to require some appreciable relearning after an interval of only five minutes.) Two ways of keeping in time with the metronome were employed. One group of subjects set the metronome at a relatively fast rate, 80 to 100, and read the first syllable of a pair on one beat, the number on the next beat, and the second syllable of the pair on the third beat, and so on. The other group of subjects set the metronome at a relatively slow rate, 60, and then read each syllable on a beat and the numbers in between beats.

The syllables used in these lists were taken from De Camp's dictionary.[1] And the numbers were taken from Tolman.[2]

Week Intervals:

Six subjects learned under the condition of A.M. *vs.* P.M. and two under those of caffeine *vs.* non-caffeine. The same numbers of lists were learned under the two contrasted conditions and in exactly parallel fashion. For the six subjects who learned under the two times of day: Subject I. learned 3 lists in the morning and 3 lists in the afternoon for each of 5 successive days. Subject II. learned 3 lists each time of day for 4 successive days. Subject III. learned 4 lists at each time of day for 4 successive days. Subject IV. learned 3 lists each time of day for 4 such successive days. Subject V. learned 4 lists each time of day on one day and 3 lists each time of day on a second day. Subject VI. learned 3 lists at each time of day on 3 successive days. Of the two subjects (VII. and VIII.) who learned under caffeine and under non-caffeine, the caffeine and non-caffeine were given on alternate days. For subject VII. 4 lists were learned a day for 10 days making 20 lists under caffeine and 20 under non-caffeine. For subject VIII. 6 lists were learned a day for 4 days making 12 lists under caffeine and 12 under non-caffeine.

The total for all eight subjects was 103 efficient learned lists and 103 inefficient learned lists or 206 in all. The syllables used in the lists had diacritical marks over the vowels and were constructed according to Tolman.[3]

The morning and afternoon subjects were members of the introductory course in psychology. The two caffeine and non-caffeine subjects were members of the advanced experimental class. All the experiments were done at home and were preceded by practice. The metronome rate was 60 for the first six subjects and 80 for the last two—one syllable per beat.

For each list the apparatus recorded the total number of repetitions and the particular syllables 'looked-at.' Using ×s to indicate 'looking-ats' and os to indicate 'not-looking-

[1] De Camp, J. E., Psychological Monographs, Vol. XIX., 1915, No. 4.

[2] Tolman, E. C., Psychological Monographs, Vol. XXV., 1918, No. 1.

[3] *Op. cit.*

ats,' we may sum this up for each list in pictures such as Figs. 1 and 2.

FIG. 1

Repetitions	1	2	3	4	5	6	7	8
Pair I	×	×	×	o	o	o	o	o
" II	×	×	×	×	×	×	×	o
" III	×	×	×	×	×	×	o	o
" IV	×	×	×	×	×	o	o	o
" V	×	×	×	×	×	o	o	o
" VI	×	×	×	o	×	o	×	o

FIG. 2

Repetitions	1	2	3	4	5	6	7	8
Pair I	×	×	o	o	o	o	×	o
" II	×	×	×	×	o	o	o	o
" III	×	×	×	×	o	o	o	o
" IV	×	×	×	×	×	×	×	o
" V	×	×	×	o	o	o	o	o
" VI	×	×	o	o	o	o	o	o

The two figures illustrate cases where the numbers of repetitions were the same—but where, in the one case, Fig. 2, the final complete recitation was preceded by considerably more partial recitations than held for the other case, Fig. 1. It is such varying proportions of partial recitations and their effects upon the later retention which we are primarily interested in. In the one case, Fig. 2, we would call the list relatively '*overlearned*' and in the other case, Fig. 1, relatively '*underlearned*.' As a single quantity to use as a measure of this under- (over-) learning for each list we counted the ×s for each pair up to the point where the *first* recitation appeared for that pair[1] and took the ratio of this number for all six pairs to the total number of ×s plus os (exclusive of the final recitation) for the six pairs. Thus in the illustrations we would have a value of 29/42 for Fig. 1, and of 22/42 for Fig. 2. For want of a better name we will call these quantities *underlearning* ratios. If the ratio is relatively large, it means that the final complete recitation was *not* preceded by much

[1] It will be noted that sometimes in the case of certain pairs (as the sixth, Fig. 1, and the first, Fig. 2), the initial 'not-looking-at' was followed by one or more later 'looking-ats.'

partial recitation; whereas, if it is small, that it *was* preceded by a considerable amount of such partial recitation.

Letting L designate the total number of learning repetitions (exclusive of the final successful recitation) and l the total number of re-learning repetitions (exclusive of the final recitation), and U the underlearning ratio in the original learning, as just defined, we obtained Pearson correlations between L and l, L and U, and l and U in the case of the five-minute intervals and in the case of the week intervals. The results were as follows, Table I.

TABLE I

	5 Min. (n = 140)	One Week (n = 206)
r_{Ll}	.371	.584
r_{LU}	.062	−.189
r_{lU}	.555	−.134

The means and sigmas were:

	5 min.		One Week	
	m	σ	m	σ
L	13.06	4.60	8.55	3.17
l	3.14	2.16	5.51	1.98
U	.711	.115	.608	.111

In order to indicate something about the reliability of these figures we may also present the correlations for the two subgroups of the efficient-learned and inefficient-learned (see above), taken separately, Table II. It is evident that the picture is practically the same as in Table I.

TABLE II

	5 Min.	
Efficient Learned	(n = 70)	One Week (n = 103)
r_{Ll}	.543	.654
r_{LU}	.025	−.326
r_{Ul}	.544	.042
Inefficient Learned		
r_{Ll}	.371	.578
r_{LU}	.062	−.073
r_{Ul}	.555	−.320

Comparing now the results for the 5-minute intervals and for the week intervals, the outstanding feature seems to be that, whereas the correlation between l and U is relatively high for the short-time retention, it was practically zero for the long-time retention. In other words, the bigger the proportion of underlearning in the original learning, the poorer the retention (*i.e.*, the bigger the l) in the relearning, if that relearning takes place after only 5 minutes. If, however, it takes place after a week, the proportion of underlearning does not seem to affect the amount forgotten at all.

That these relations are really true appears more surely when we compute the partial correlations between l and U with L partialled out, Table III. In other words, when all

TABLE III

	5 Min. (n = 140)	One Week (n = 206)
$r_{lU \cdot L}$	.574	−.037

the effects due to mere differences in the numbers of original repetitions are partialled out (when, that is, all the effects due to the varying ability of the different subjects and of varying difficulty in lists for the same subject are discounted), it still remains true that there is a relatively pronounced correlation between underlearning *per se* and forgetting after 5 minutes but no such relation between it and forgetting after one week. It seems, in short, that whereas the lack of extra recitations, which is the accompaniment of a large U, is injurious to immediate retention, it does not affect permanent retention.[1]

How are we to explain this result? The explanation which occurs to us is that perhaps it is a matter of perseveration and association in the Müller and Pilzecker[2] sense. These authors, it will be recalled, came to the conclusion that whereas short-time retention (*i.e.*, up to five or ten minutes)

[1] One other possibility suggests itself—namely, that our difference in results was due to the fact that for the short-time tests we used syllable-number-syllable pairs, whereas in the long-time tests we used syllable-syllable pairs. That this difference should have really been the true cause of our results we cannot, however, well believe.

[2] Müller, G. E. und Pilzecker, A., Zeitschrift für Psychologie, Ergänzungsband II, 1903.

is much affected by what they called the perseveration or 'Nachklingen' of the original excitations, retention after a longer interval was due to association bonds only. If, now, we assume further that the extra recitation, accompanying a small U, is perhaps primarily effective in increasing perseveration (Nachklingen) rather than in strengthening the permanent association bonds, we have our required explanation. The greater recitation (*i.e.*, a small U) produces relatively great perseveration and this tends to produce a better retention (*i.e.*, a small l) in the short-time tests (where perseveration can still play a part), but can have no effect upon the long-time tests (in which perseveration is no longer operative).

One result of side interest is to be noted, namely, that there are higher correlations between L and l for the week intervals than for the 5-minute intervals. And this appears even more definitely when the effects due to variations in U are partialled out, Table IV. This means that, where the

TABLE IV

	5 Minutes	One Week
$r_{Ll \cdot U}$	.406	.770

interval is great, the difficulties of relearning of a given list are much more comparable to those of its original learning than is the case where the interval is small and differences of retentivity play more of a part.

Finally, we may sum up as follows:

(1) A new apparatus which permits the recording of 'under- (over-) learning' has been described.

(2) A decided correlation between the degree of 'under-learning' and the degree of forgetting after 5 minutes was found whereas no correlation was found between 'under-learning' and forgetting after one week.

(3) It was suggested that this might be explained as due to the fact that overlearning increases 'perseveration' more than it does association.

(4) There was more correlation between learning and relearning in the case of the long-time tests than in that of the short-time tests.

PSYCHOLOGICAL REVIEW PUBLICATIONS

Original contributions and discussions intended for the Psychological Review should be addressed to

Professor Howard C. Warren, Editor PSYCHOLOGICAL REVIEW,
Princeton, New Jersey.

Original contributions and discussions intended for the Journal of Experimental Psychology should be addressed to

Dr. John B. Watson, Editor JOURNAL OF EXPERIMENTAL PSYCHOLOGY.
244 Madison Avenue, New York

Contributions intended for the Psychological Monographs should be addressed to

Dr. James R. Angell, Editor PSYCHOLOGICAL MONOGRAPHS,
Yale University, New Haven, Conn.

Reviews of books and articles intended for the Psychological Bulletin, announcements and notes of current interest, and *books offered for review* should be sent to

Dr. S. I. Franz, Editor PSYCHOLOGICAL BULLETIN,
St. Elizabeth's, Washington, D. C.

Titles and reprints intended for the Psychological Index should be sent to

Professor Madison Bentley, Editor PSYCHOLOGICAL INDEX,
University of Illinois, Urbana, Ill.

All business communications should be addressed to

Psychological Review Company,
Prince and Lemon Streets, Lancaster, Pa., and Princeton, New Jersey

---

PHILOSOPHICAL MONOGRAPHS

VOL. I

1. Aesthetic Experience: Its Nature and Function in Epistemology. W. L. FURRY. Pp. xvi + 150. $1.60. 2. The Philosophy of John Norris of Bemerton. FLORA ISABEL MACKINNON. Pp. iii + 103. $1.00. 3. Freedom and Purpose. An Interpretation of the Psychology of Spinoza. JAMES H. DUNHAM. Pp. iv + 126. $1.25.

LIBRARY OF GENETIC SCIENCE AND PHILOSOPHY

Vol. 1. The Moral Life. A Study in Genetic Ethics. By ARTHUR ERNEST DAVIES, PH.D., Professor of Philosophy in Colorado College. xiv + 188 pages. 8vo. Cloth. Price, $1.50 net. Postage, 10 cents.

Vol. 2. Darwin and the Humanities. By JAMES MARK BALDWIN. viii + 118 pages. 8vo. Cloth. Price, $1.50 net. Postage, 8 cents.

Published by

PSYCHOLOGICAL REVIEW COMPANY

Directory of American Psychological Periodicals

American Journal of Psychology—Ithaca, N. Y.: Morrill Hall.
Subscription $6.50. 600 pages annually. Edited by E. B. Titchener.
Quarterly. General and experimental psychology. Founded 1887.

Pedagogical Seminary—Worcester, Mass.; 950 Main Street.
Subscription $5. 575 pages annually. Edited by G. Stanley Hall.
Quarterly. Pedagogy and educational psychology. Founded 1891.

Psychological Review—Princeton, N. J.; Psychological Review Company.
Subscription $4.25. 480 pages annually.
Bi-monthly. General. Founded 1894. Edited by Howard C. Warren.

Psychological Bulletin—Princeton, N. J.; Psychological Review Company.
Subscription $5. 720 pages annually. Psychological literature.
Monthly. Founded 1904. Edited by Shepherd I. Franz.

Psychological Monographs—Princeton, N. J.; Psychological Review Company.
Subscription $5.50 per vol. 500 pp. Founded 1895. Ed. by James R. Angell.
Published without fixed dates, each issue one or more researches.

Psychological Index—Princeton, N. J.; Psychological Review Company.
Subscription $1.50. 200 pp. Founded 1895. Edited by Madison Bentley.
An annual bibliography of psychological literature.

Journal of Philosophy—New York: Sub-Station 84.
Subscription $4. 728 pages per volume. Founded 1904.
Bi-weekly. Edited by F. J. E. Woodbridge and Wendell T. Bush.

Archives of Psychology—Sub-Station 84, N. Y.; Archives of Psychology.
Subscription $3. 500 pp. per vol. Founded 1906. Ed. by R. S. Woodworth.
Published without fixed dates, each number a single experimental study.

Journal of Abnormal Psychology and Social Psychology—Boston:
Subscription $5. Richard G. Badger. Edited by Morton Prince.
Bi-monthly. 432 pages annually. Founded 1906. Abnormal and social.

Psychological Clinic—Philadelphia; Psychological Clinic Press.
Subscription $2.50. 288 pages. Ed. by Lightner Witmer. Founded 1907.
(Without fixed dates (9 numbers). Orthogenics, psychology, hygiene.

Training School Bulletin—Vineland, N. J.; The Training School.
Subscription $1. 160 pages ann. Ed. by E. R. Johnstone. Founded 1904.
Monthly (10 numbers). Psychology and training of defectives.

Comparative Psychology Monographs—Baltimore; Williams & Wilkins Co.
Subscription $5. 500 pages per volume. Edited by W. S. Hunter.
Published without fixed dates, each number a single research.

Psychoanalytic Review—Washington, D. C.; 3617 10th St., N. W.
Subscription $4. 500 pages annually. Psychoanalysis.
Quarterly. Founded 1913. Ed. by W. A. White and S. E. Jelliffe.

Journal of Experimental Psychology—Princeton, N. J.
Psychological Review Company. 480 pages annually. Experimental.
Subscription $5.25. Founded 1916. Bi-monthly. Ed. by John B. Watson.

Journal of Applied Psychology—Worcester, Mass.: Florence Chandler.
Subscription $3. 400 pages annually. Founded 1917.
Quarterly. Edited by James P. Porter and William F. Book.

Journal of Comparative Psychology—Baltimore: Williams and Wilkins Company.
Subscription $5. 500 pages annually. Founded 1921.
Bi-monthly. Edited by Knight Dunlap and Robert M. Yerkes.

EzP